HANDBOOK OF SERICULTURE.

BY

N. G. MUKERJI, M.A., M.R.A.C. & F.H.A.S.

RAR
638.2
MUK

[Price—Indian, Rs. 5; English, 7s. 6d.]

HANDBOOK OF SERICULTURE,

BY

NITYA GOPAL MUKERJI, M.A.,

OF THE BENGAL PROVINCIAL CIVIL SERVICE, HOLLAND GOLD MEDALLIST
OF THE ROYAL AGRICULTURAL COLLEGE, CIRENCESTER (ENGLAND),
AND FELLOW OF THE HIGHLAND AND AGRICULTURAL
SOCIETY (SCOTLAND).

"A bold peasantry, their country's pride,
When once destroyed can never be supplied."

—*Goldsmith.*

CALCUTTA :
BENGAL SECRETARIAT BOOK DEPÔT.
1919.

638.2
MUK

Published by the BENGAL SECRETARIAT BOOK DEPÔT,
Writers' Buildings, Calcutta.

OFFICIAL AGENTS.

In India—

Messrs. Thacker, Spink & Co., Calcutta and Simla.
Messrs. Newman & Co., Calcutta.
Messrs. Higginbotham & Co., Madras.
Messrs. Thacker & Co., Ld., Bombay.
Messrs. A. J. Combridge & Co., Bombay.
The Superintendent, American Baptist Mission Press, Rangoon.
Mrs. Radhabai Atmaram Sagoon, Bombay.
Messrs. R. Cambray & Co., Calcutta.
Rai Sahib M. Gulab Singh & Sons, Proprietors of the Mufid-i-am Press, Lahore, Punjab.
Messrs. Thompson & Co., Madras.
Messrs. S. Murthy & Co., Madras.
Messrs. Gopal Narayan & Co., Bombay.
Messrs. B. Banerjee & Co., 25, Cornwallis Street, Calcutta.
Messrs. S. K. Lahiri & Co., Printers and Booksellers, College Street, Calcutta.
Messrs. V. Kalyanarama Iyer & Co., Booksellers, etc., Madras.
Messrs. D. B. Taraporevala & Sons, Booksellers, Bombay.
Messrs. G. A. Natesan & Co., Madras.
The Indian School Supply Depôt, 309, Bow Bazar, Calcutta.
Mr. Ramnath Sunder, Bombay.
Messrs. A. M. and J. Ferguson, Ceylon.
Messrs. Temple & Co., Madras.
Babu S. C. Talukdar, Proprietor, Students & Co., Cooch Behar.
Messrs. Ram Chandra Govind and Sons, Booksellers and Publishers, Kalbadevi, Bombay.
Messrs. Butterworth & Co. (India), Ld., Calcutta.
The Weldon Library, 18-5, Chowringhee Road, Calcutta.
Rai M. C. Sarkar Bahadur & Sons, 90-2A, Harrison Road, Calcutta.
The Proprietor of the Newal Kishore Press, Lucknow.
The Standard Literature Company, Limited, 13-1, Old Court House Street, Calcutta.
Mr. G. N. Halder, Calcutta.
Messrs. Vas & Co., Madras.
Messrs. A. H. Wheeler & Co., Allahabad, Calcutta & Bombay.
M. R. Ry. E. M. Gopalakrishna Kone, Madras.
Messrs. Rama Krishna and Sons, Anarkali Street, Lahore.
The Manager, "Hitavada," Nagpur.
The Young Men's Christian Association Press, Calcutta.
Messrs. Lal Chand & Sons, 76, Lower Circular Road, Calcutta.
The Standard Book Stall, Karachi.

In Great Britain—

Messrs. A. Constable & Co., 10, Orange Street, Leicester Square, London, W.C.
Messrs. Grindlay & Co., 54, Parliament Street, London, S. W.
Messrs. Kegan, Paul, Trench Trübner & Co., 68-74, Carter Lane, London, E. C.; Oriental Dept., 25, Museum St., London, W.C.
Mr. B. Quaritch, 11, Grafton Street, New Bond Street, London, W.
Messrs. W. Thacker & Co., 2, Creed Lane, Ludgate Hill, London, E.C.
Messrs. P. S. King & Son, 2 & 4, Great Smith Street, Westminster London, S.W.
Messrs. H. S. King & Co., 65, Cornhill, London, E.C.
Mr. B. H. Blackwell, 50-51, Broad Street, Oxford.
Messrs. Deighton Bell & Co., Ltd., Trinity Street, Cambridge.
Messrs. Luzac & Co., 46, Great Russell Street, London, W.C.
Messrs. Oliver & Boyd, Tweeddale Court, Edinburgh.
Messrs. E. Ponsonby, Ltd., 116, Grafton Street, Dublin.
Mr. T. Fisher Unwin, Limited, 1, Adelphi Terrace, London, W.C.
Messrs. William Wesley & Son, 28, Essex Street, Strand, London.

On the Continent—

Mr. Ernest Leroux, Rue Bonaparte, Paris, France.
Mr. Martinus Nijhoff, The Hague, Holland.

I.G.N.C.A. LIB.
86-3188
Deptt of Arts
12-12-86
GOVT. OF INDIA

SV05

Indira Gandhi National Centre for the Arts

CONTENTS.

HANDBOOK OF SERICULTURE.

PART I.

THE MULBERRY AND THE MULBERRY SILKWORM.

PAGE.
CHAPTER I.—Varieties of Mulberry 1
" II.—The Bengal System of Mulberry Cultivation . 4
" III.—Propagation of large Mulberry Trees . . . 13
" IV.—Rearing of Silkworm 21

PART II.

DISEASES OF SILKWORMS AND OF THE MULBERRY PLANT.

CHAPTER I.—General Cause of Diseases and General Remedies 41
" II.—Use of the Microscope 46
" III.—Katá or Pebrine 53
" IV.—Chuná-kété, Chhit or Muscardine . . . 74
" V.—Rasá or Grasserie 87
" VI.—Kálshirá and Shalfá (Flacherie and Gatine) . . 95
" VII.—Láli (*Court*), Gájlá-koá (*Satinè* Cocoons) and Génthé-koá (Double Cocoon) 109
" VIII.—The Silkworm-fly and the Dermestes . . . 112
" IX.—Diseases of the Mulberry Plant 121
" X.—The Grainage 128

PART III.

THE COMMERCIAL COCOONS.

CHAPTER I.—Various kinds of Silkworms 151
" II.—The Barapalu 155
" III.—European Silkworms 162
" IV.—Rearing of Tusser Silkworms 170
" V.—Rearing of the Eri Silkworm 184

PART IV.

MANUFACTURE AND COMMERCE.

PAGE.

CHAPTER I.—Waste Silk 195
„ II.—Reeling of Silk 199
„ III.—Winding, Warping, and Weaving 221
„ IV.—Bleaching and Dyeing (Native Processes) . . 228
„ V.—Bleaching and Dyeing (European Methods) . . 245
„ VI.—Testing of Silk 256
„ VII.—Preparation of Silkworm guts 268
„ VIII.—Artificial Silk 269
„ IX.—Silk Trade 272

APPENDIX 291

PREFACE.

A MANUAL of sericulture was published by the author in the Bengali language in 1894 for the use of the silkworm-rearing peasantry of Bengal. An English translation of this manual was prepared under the orders of the Director of the Department of Land Records and Agriculture. The publication of this translation was authorised under Government order No. 1040 Agri., dated the 26th February 1896. In publishing the present Handbook, the translation has been so revised that the book may appear as an original work, and meet the requirements of sericulturists both in India and in the British Colonies. Sericultural enterprise has been undertaken in various Provinces of India, and also in different Colonies, and the want of a Handbook has been felt. Applications have been received from time to time either by the Agricultural Department or by the author for a reliable book on sericulture, and the publication of the present Handbook may, it is hoped, supply a want and give an impetus to the silk industry of India and the British Colonies. The principal drawback to sericultural enterprise everywhere has been, of late years, the wholesale death of silkworms from certain diseases when they are reared on any considerable scale. The author having been employed by the Government of Bengal for nearly ten years in the investigation of silkworm epidemics, Part

II of the Handbook gives information derived from actual experiments confirmed by subsequent trials conducted successfully and with pecuniary profit by intelligent cocoon-rearers in most of the silk districts of Bengal. A sericultural school has been established at Rampur Boalia mainly with the object of training cocoon-rearers in the art of avoiding silkworm epidemics, and it is doing very good work in disseminating the knowledge derived from the experiments. Part IV of this book, however, dealing with questions of manufacture and trade, with which the author has no intimate acquaintance, is added chiefly to give the book the character of completeness.

With the approval of the Director of the Department of Land Records and Agriculture, the Appendix to the Bengali version, which deals with certain agricultural matters, is omitted in the present Handbook, as having little connection with the main subject. The other alterations are unimportant, and they need not be specially mentioned.

NITYA GOPAL MUKERJI,
Professor of Agriculture,
Civil Engineering College, Sibpur.

SIBPUR,
The 10th October 1918.

HANDBOOK OF SERICULTURE.

PART I.

THE MULBERRY AND THE MULBERRY SILKWORM.

CHAPTER I.

Varieties of Mulberry.

Morus Alba.—There are many kinds of mulberry, of which *Morus Alba* (varieties, *Indica* and *Lœvigata*) and *Morus Serrata* grow wild in the Himalayas. Other varieties have been also introduced in this country with success. These are —*Morus Nigra, M. Multicaulis, M. Sinensis,* and *M. Philippinensis.* A spiney climbing plant, botanically allied to mulberry and called in America Osage orange (*Maclura Aurantiaca*), has been also introduced in this country with success, and found useful for rearing mulberry silkworms of all kinds. All varieties of mulberry are not equally suited for rearing every kind of silkworm. The mulberry tree which we usually see in gardens, and which yields large-sized, black-coloured and luscious fruit, is the *Morus Nigra.* The leaves of this tree are rather coarse, and not quite suitable for rearing silkworms. Silkworms of the *Chhotapalu* (*Bombyx fortunatus*) variety take the disease called flacherie if they are reared on *M. Nigra* leaf to the last. Other varieties of mulberry silkworms can be reared with *M. Nigra* leaf. But so reared, the silkworms yield a less proportion of silk and that of an inferior quality. *M. Indica, M Lœvigata, M. Multicaulis, M. Sinensis,* and *M. Philippinensis* may be regarded as different varieties of *M. Alba.* Of these, *M. Multicaulis* may be regarded as the best for rearing silkworms. The leaves of *M. Multicaulis* are very large and tender. They are thick, but not coarse. The tree grows fast and attains a greater height than other varieties of

M. Alba. The internodes being very short, the yield of leaf of this variety of mulberry is greater than that of any other variety. Next to *M. Multicaulis, M. Alba* of Europe may be considered the best variety for silkworms. This variety of mulberry grows just as well in this country as the indigenous varieties. The indigenous varieties of *M. Alba* differ in size, shape, and texture of leaf, also in quantity, size and colour of the fruit, and in the height to which the trees attain. But the lines of distinction are not fixed. A cutting taken from a tree with ovate leaves only often produces a tree with palmate leaves and *vice versâ.* On the same tree palmate and ovate leaves are sometimes found indifferently. Some varieties yield little or no fruit: some abound in fruits. The fruits when ripe are either white, purple, or black. White, purple, and black fruits are sometimes found indifferently on the same trees. The soil on which they grow and the manner in which they are cultivated have very great effect on their nutritive value to silkworms and in altering the shape and texture of leaves. In the laterite soil of Birbhum the leaves become thick and usually ovate and dark-coloured. In clay soil also the leaf becomes dark-coloured, but not so thick. In sandy soil the leaf becomes light-coloured and usually palmate. In Midnapore the plants are allowed to grow for three years before they are coppiced, the leaves being picked for silkworms instead of branches; while in Murshidabad, Rajshahi, Malda, Birbhum, and Nadia the plants are cut down three or four times every year. This difference in treatment has a marked effect on the properties of the leaf. In Midnapore the mulberry is well adapted for the *Bombyx textor* variety of silkworms, but not so well adapted for the *B. fortunatus* variety; while in the other districts, where coppicing is freely done, the mulberry is not so well adapted for the *B. textor,* though it is better adapted for the *B. fortunatus.*

2. *Morus Serrata.*—The *Morus Serrata* differs very much from the other varieties that have been mentioned, and the line of distinction between this and the other varieties of mulberry is clearly marked. It attains the very great height

of 80 or 90 feet. It prefers a low and damp situation. It grows wild in the valleys of Bhutan and Sikkim; while *M. Alba* grows wild at a higher elevation, chiefly at an elevation of 3,000 to 4,000 feet above the sea-level. The timber of the *M. Serrata* is most valuable, and it is chiefly useful for making furniture. In Bhutan and Sikkim the tree is freely lopped, and the leaves used as cattle food, the tender leaves being also cooked and eaten by men as a potherb. The fruit of the *M. Serrata* remains green when ripe. It is 5 or 6 inches long, that is longer than the fruit of any other kind of mulberry. It is sweet and without any acid taste when ripe. For rearing silkworms leaves of *M. Serrata* are just as useful as those of *M. Alba:* for the *B. fortunatus* variety of silkworms, however, it is not suitable. In fact, for these silkworms the constantly-coppiced *M. Indica* is the best.

3. *Other Food-plants.*—Besides mulberry and Osage orange, lettuce leaves and *tender* leaves of the ordinary *peepul* (*Ficus religiosa*) tree may be mentioned as suitable for rearing mulberry silkworms during the early stages of their growth. They cannot be depended upon at the last stage, as they very seldom enable silkworms to spin cocoons. Still the information is of very great practical value, when in the spring the mulberry is backward. Young worms may be reared on tender *peepul* leaves for 15 to 20 days, and the mulberry allowed to grow uninterruptedly in the meantime. A difference of 15 to 20 days in the spring makes a great difference in the growth of the mulberry. In cold climates lettuce may, under similar circumstances, be used while the mulberry is putting forth new leaves.

4. *Choice of Mulberry.*—In choosing a variety of mulberry out of several for rearing silkworms in any locality where the help of a botanist is not available, the following criteria should be followed:—

1st.—A tree that yields little or no fruit should be preferred.

2nd.—Where all the trees yield about the same quantity of fruits, the tree that yields the smallest and the most insipid fruits should be preferred.

3rd.—Other conditions being equal, the tree that bears the largest sized leaves should be preferred.

4th.—Other conditions being equal, the tree that bears the largest quantity of leaf should be preferred.

5th.—Other conditions being equal, the tree that grows fastest should be preferred.

6th.—It is of the greatest importance for sericulture that mulberry leaves should be smooth, succulent, and thick, but not leathery.

N.B.—Trees from seed usually produce thinner leaves than those from grafts or cuttings. Thin-leaved varieties of mulberry are useful for feeding worms in the early stages, but at the last stage thick leaves should be preferred, provided they are succulent.

CHAPTER II.

THE BENGAL SYSTEM OF MULBERRY CULTIVATION.

5. *Disadvantage.*—In Bengal the mulberry plant is usually grown in little clusters, 6 or 7 cuttings being planted together at a distance of 18 to 27 inches. The plants growing so close to one another never get the opportunity of attaining their natural size, but always remain dwarfed and stunted. When they attain the height of 2 or 3 yards they require to be cut or coppiced, or else they wither and kill one another out. If they were allowed more space they would have grown into trees; but it is impossible for plants to develop into trees when they are grown so close together. Under the Bengal system of mulberry cultivation, plants are cut away or their leaves used at least three times during the year: that is, with the Bengal mulberry it is necessary to take three crops of silkworms in one year, or else the leaf gets too strong. It is not always an advantage to have to rear three crops of cocoons, whether the season is favourable or not. Land put down under Bengal mulberry also requires to be dug or hoed three or four times in the year, or else weeds get the better of mulberry. Under the Bengal system of cultivation, it is also

necessary to apply manure or earth to mulberry fields once a year. If this is not done, the growth of the plants falls off rapidly. This system, therefore, requires expenditure of money or of labour every year. Another disadvantage of this system is that it cannot be pursued on lands subject to inundation.

6. *Advantage.*—In other countries where sericulture is carried on, the mulberry plant is allowed to grow into a tree before the leaves are used. If mulberry trees are propagated 80 to 100 feet apart in corn-fields, corn and silk may be both grown. Trees do not run the risk of perishing by the overgrowth of weeds, or by inundation, or drought, or by the soil getting exhausted. But there is one special advantage in growing mulberry on the Bengal system. Where sericulture is introduced for the first time, it is best to do it by planting a small plot of mulberry on the Bengal system for facility of instruction in the rearing of silkworms. The cuttings may be planted in January or February, and rearing of silkworms commenced next September; or the cuttings may be planted in September or October, *i.e.*, soon after the rains have ceased, and rearing of silkworms commenced in December or January; or the plants may be propagated from seed sown in July in pots protected from sun and rain, the seedlings being transplanted in September, and the rearing of silkworms commenced in January. Mulberry being kept up on the Bengal system, it is possible to take 3, 4, or even 5 crops of cocoons during the year, and if alternate plots of land are used, 8 crops of cocoons can be taken in succession in one year. In this way a large number of persons can be annually taught silk-rearing, and they can be also encouraged to carry out what they have learnt in their own houses by allowing them to propagate mulberry on the Bengal system from cuttings given away at the place of instruction. But after 4 or 5 years, when a sufficient number of cultivators have been trained in rearing silkworms, the Bengal system of mulberry cultivation should be abandoned, trees being propagated in the meantime which will bear stripping on the 4th or 5th year after planting. The

Bengal system is to be followed only on a small scale, and for the purpose of practising silkworm rearing; but one should depend ultimately on large trees only. The propagation of large trees and of the Bengal mulberry should be undertaken simultaneously. When after 4 or 5 years the cultivator will see a number of large mulberry trees ready for use, he will naturally neglect his plot of Bengal mulberry, which requires such constant attention.

7. *Land.*—All kinds of land are suitable for mulberry, that is mulberry will grow where other plants will grow. Consequently, no difficulty need be apprehended on this score, if it is desired to introduce sericulture in a new locality. In cold climates the Bengal system of cultivation is not likely to answer, as severe frost would kill shallow-rooted plants. In such climates large trees should be propagated before silk-rearing is commenced. Though the Bengal mulberry will grow on any kind of soil, it should be remembered that it is a perennial crop and more valuable than most agricultural crops; and for this reason the best plot of land and the richest soil should, as a rule, be set apart for mulberry. Clay soil lying fallow for a number of years, or soil prepared by uprooting stumps of bamboo from an old bamboo garden, is most eminently suited for growing mulberry. For propagating large trees, fertile soil need not be looked for. The mulberry garden should be close to the house, but it must be exposed to the full light of the sun. Proximity to the house is required for this reason: the mulberry plant is food not only of the silkworm, but also of goats and cattle. As it is more profitable feeding the silkworm with mulberry, watch should be kept that goats and cattle do not get to eat it. As the Bengal mulberry always remains dwarf, this watch is required perpetually for its protection. Large trees do not require to be permanently protected; and it is enough for propagating trees to transplant them from the nursery into fields after they have attained the height of 9 or 10 feet, and to put gabions round them until they become strong enough to stand by themselves.

8. *Ditching and Fencing.*—After selecting the plot of land suitable for a mulberry garden, a ditch should be dug round it, and the earth dug up kept in heaps all round the garden. It should be also encircled with a fence. The fence can be put up after the cultivation and the planting of cuttings are over. The earth heaped up all round the garden can be used as manure in the second year. After this, annually, or every alternate year, earth can be dug up from the trench surrounding the garden, and applied as manure in April or May. This application of earth every year, or every other year, helps to raise the level of the Bengal mulberry land 5 or 6 feet above the surrounding country in the course of 20 or 30 years, and a wide ditch is gradually formed round it. But if cultivation on the Bengal system is resorted to only for 4 or 5 years, the land can be easily utilized for other crops afterwards, as its elevation will be very slight and the ditch not too deep.

9. *Cultivation.*—After selecting the land, it should be dug up in the cold weather, more than a foot deep, with spades. It should be then left untouched until May, when the first ploughing should be done after a shower of rain, both lengthwise and crosswise. In June, July and August also ploughing should be done once a month. In September or October, that is as soon as the rains are over, three or four ploughings and ladderings (harrowings) are required for bringing the land to a proper tilth. Then the lines along which the cuttings are to be planted should be marked with a spade, scooping out a lump of earth 18 inches apart alongside a string used for this purpose. The cuttings are planted in the hollows made with the spade. If the cuttings are planted in January or February, the first digging of the earth can be done in November, and the cultivation in December and January. In this case the cuttings should be planted in trenches. In dry, harsh, laterite soils planting of cuttings should be done in trenches even in September and October. When the plants are cut away for the first time in April, the earth from the ridges should be spread on to the trenches,

making the whole field level. Next year in April, again, trenches should be made betweeen the rows of plants, the earth being spread over the roots of the plants, which will serve to make them lie along ridges. By this means necessity is avoided for applying manure or earth from outside for two years. If cuttings are planted in September, they should not be ordinarily placed in trenches, as late rains may fill them up with water and the cuttings may rot away in consequence. In Bengal cuttings are planted in September and October on the Murshidabad side, and in January and February on Midnapore side. In the Garhbeta subdivision of Midnapore, where the soil is very harsh, planting of cuttings is done as soon as the rains are over, *i.e.*, early in September, and in trenches. Where the soil is naturally dry, cuttings should be planted in September, when there is sufficient moisture in the soil. Where the soil is naturally moist cuttings should be planted in January in trenches. Planting cuttings in trenches, one saves the expenditure he would otherwise incur for manuring his mulberry for two years running.

10. *Cuttings.*—Mature stalks of mulberry, but not thicker than a man's thumb, should be held in bundles of 10 or 12 at a time with the left hand, and successive strokes from a bill-hook held with the right hand should sever each time 10 or 12 cuttings, each 9 inches long, the bundle of mulberry stalks being placed on a thick block of wood to help the operation. While the cuttings are being made by persons sitting under the shade of a tree, the planting may go on at the same time. But it is possible to keep the cuttings alive even for a month if they are kept heaped up in shade and watered at the interval of 3 or 4 days. Whether the cuttings are planted on level land or in trenches, 6 or 7 of them should be put in each hollow made with the spade a few inches apart from each other. It should be seen that the eyes or buds look upwards when the cuttings are planted. They will not put forth shoots if they are planted upside down. It should be also seen that they are planted in a slanting way, at about 60° inclination. If the planting is done in January or February, only an inch

should remain sticking out of, and the remaining portion buried in, the soil. If the planting is done in September or October, a little more should remain sticking out, or else late rains may cause them to rot. In dry, laterite soils, cuttings may be buried altogether even in September. It should not rain immediately before or after the planting of cuttings. If it does, the soil getting caked, obstruction is caused to the shooting of buds. Under such circumstances the soil round the cuttings requires to be carefully hoed or loosened. When after planting the cuttings, the shoots appear in uniform lines 4 or 5 inches above ground, hoeing should be done. The plough should not be used to get over this work more easily, as the cuttings getting shaken, the plants may wither away and die. Two months and a half after the planting of cuttings, the shoots ought to stand 20 to 30 inches above ground. When they are of this height, they should be cut away close to the ground. The leaves of these shoots are very thin and tender. They are called "*naicha* leaves." If silkwroms at the last stage are fed on *naicha* leaves they get the disease called grasserie, or else poor cocoons are produced. It is best to give these first cut leaves to cattle, or use them for rearing young worms. After the first shoots are cut away, ploughing should be done between the rows of plants. If the plants are in trenches, the plough being passed through the ridges, the soil will naturally topple over to the trenches, making the field level. If the cuttings are planted in September, this first ploughing should be given in November; and if they are planted in January, this ploughing should take place in April. The shoots that will appear after this ploughing can be used for rearing silkworms. In other words, it is possible to begin silk-rearing in January if cuttings are planted in September; and in June if cuttings are planted in January, and even earlier. If planting of cuttings is done in September, the earth, already spoken of as being heaped up all round the field, should be spread over it in the following April.

11. *Manuring the Mulberry.*—Earth dug out from tanks or trenches is excellent manure for mulberry. Five cart-loads of indigo refuse, 10 cart-loads of rotten dung, 2 cart-loads of rotten silkworm droppings, or half a maund of saltpetre, per bigha (about ⅓ acre), are also suitable manures for mulberry

land. Without manure it is impossible to keep Bengal mulberry in condition. After the mulberry stalks are cut away in August or September in preparation for the November *bund*, a luxuriant growth of mulberry can be got in November if saltpetre is spread over the field after the stalks are cut away. When saltpetre is used as manure, it is necessary also to continue the earthing or manuring, which is done annually in April or May, as saltpetre helps to dissolve plant food of the soil, and makes a large quantity of it available at one time, forcing the growth of the plants for a season only. In using saltpetre as a top dressing, another thing should be borne in mind—it should not be sprinkled on leaves. It burns up leaves by contact. It should therefore be applied as suggested after the plants are cut away in August or September, or else mixed up with water with which the mulberry field is irrigated.

12. *Other Operations.*—After the April or May manuring, the plough should be passed twice through the field, which will also help to kill weeds. In June the plants will be again ready for cutting. In some villages silk-rearers object to using the June crop of mulberry. They let it stand until July. This helps the development of the stems of the plants, which is helpful to vigorous growth of shoots in November, when every cocoon-rearer desires to have a luxuriant crop of mulberry. If the June crop of mulberry is used for silk-rearing, another rearing can take place in August. If two crops of silkworms are raised during the rainy season by cutting away whole stalks of mulberry, the growth in November is not so satisfactory. But this difficulty can be avoided by gathering leaves and tender shoots only in June (instead of whole stalks), which enables another crop to be taken in August; while the stem development going on with little interruption, the growth in November also is excellent. On the Murshidabad side cultivators have great prejudice against using mulberry in June, but in Bogra and Midnapore, leaves being stripped in June, no harm is done to the November crop of mulberry. If Murshidabad silk-rearers follow this plan, they can take an extra crop of cocoons with impunity. Whether the June crop is used or not, the field should be thoroughly weeded in July. When the mulberry is cut in July or August, only the top portions of the plants are gathered. The mature stalks

below are cut away afterwards, in August or September, close to the ground. These stalks are useful for making cuttings for extending plantations. After the stalks are cut away the land is well cultivated. The shoots coming up afterwards are used for the November crop of silkworms. After the November *bund*, the land again requires to be ploughed, either in November or in December.

13. *Irrigation.*—Mulberry is very rarely grown by irrigation. Where, however, facility exists for irrigation, it should be resorted to, as it helps two extra growths, *i.e.*, in addition to the November, March, June, and August cuttings, two more cuttings can be taken in January and May, helping one to take six cocoon crops in place of four. In some Bengal villages, in fact, six cocoon crops are taken during the year.

14. *Expense.*—The expense for the first two years required for establishing a field of Bengal mulberry 1 bigha in extent is detailed below:—

	Rs.	A.	P.
Wages of 30 men employed in digging the field with spades in the cold weather at 3 annas	5	10	0
Ditching and fencing (by piece-work)	10	0	0
Cost of 12 ploughings, the ploughmen with ploughs and bullocks being hired at 4 annas a day	3	0	0
Cost of getting 10 loads of mulberry stalks at 4 annas	2	8	0
Wages of 5 men making cutting at 3 annas	0	15	0
Ditto 5 men making hollows in regular lines	0	15	0
Ditto 15 men planting cuttings	2	13	0
Hoeing in September (by piece-work)	0	8	0
Ploughing after the cutting away of the first shoots	1	8	0
Cost of putting earth in April or May (by piece-work)	5	0	0
Ploughing in May	0	12	0
Irrigating (if done) in May	5	0	0
Weeding in July (piece-work)	1	0	0
Cutting of stumps in August or September	0	8	0
Ploughing in September	0	8	0
Digging with spades after the November *bund*	2	8	0
Two years' rent	4	0	0
Total	47	1	0

For irigation, earthing, and rent the expense may be curtailed in some localities; but one must be prepared to spend between Rs. 40 and Rs. 50 for starting a bigha of mulberry, or about Rs. 150 per acre.

15. *Outturn.*—When cuttings are planted in September or October, the November crop of mulberry may be sold; but

being *naicha* leaf, it should be given to cattle instead of being sold to a cocoon-rearer, who may give it to worms in the last stage by mistake, and cause grasserie in consequence. This crop is not included in the following calculation:—

				Rs.	A.	P.
8	maunds of mulberry leaf obtained in	January,	sold for	8	0	0
12	,, ,, ,, ,,	March	,,	12	0	0
16	,, ,, ,, ,,	June	,,	8	0	0
20	,, ,, ,, ,,	August	,,	10	0	0
15	,, ,, ,, ,,	November	,,	30	0	0
15	,, ,, ,, ,,	December	,,	15	0	0
86		Total	...	83	0	0

16. Two years after the plantation is started, a bigha of mulberry should yield annually about 100 maunds of leaf. To get a regular yield of 100 maunds of Bengal mulberry leaf per annum, it is necessary to cultivate the land very thoroughly. In the district of Malda, where mulberry land is well manured and kept highly cultivated, 200 to 250 maunds of leaf per annum per bigha is not an unusual yield. With 100 maunds of mulberry leaf one can produce 200 seers of cocoons. Cocoons when cheap may be had two seers for the rupee. For seed purpose cocoons are sometimes bought as dear as Rs. 2 a seer. In other words, from a bigha of mulberry one can raise from Rs. 100 to Rs. 400 worth of cocoons, and sometimes more.

17. *Annual Expenditure.*—When the mulberry plantation on the Bengal system has been started, expense has to be incurred in keeping it up permanently. The details of such expense for 1 bigha are given below:—

	Rs.	A.	P.
Cutting of *murhas* or stumps in September ...	0	12	0
Two ploughings	0	8	0
Weeding in October	1	0	0
Spading done superficially after the November crop of leaf is sold	1	0	0
Subsequent weeding	0	12	0
Thorough digging in January (32 men)	6	0	0
Earthing or manuring in April or May	5	0	0
Irrigating in May	5	0	0
Superficial digging at the end of May	1	0	0
Weeding in July	2	0	0
Rent	2	0	0
Total ...	25	0	0

18. *Sowing of Seed.*—Detailed description has been given of raising mulberry plants from cuttings. It has been incidentally mentioned that the plants can be also propagated from seed. Where the mulberry plant exists, procuring of cuttings is easy; but where the plant does not exist, and where sericulture is newly introduced, it is more convenient to propagate the plants at first from seed. To extend the plantation further in after years cuttings should be used, as leaf obtained from plants grown from cuttings is thicker and better as a rule than leaf obtained from seedlings. The seedlings can be transplanted into fields at the end of the rainy season and planted close together in clumps, after the Bengal fashion, or a different system may be adopted for propagating trees. How seedlings are grown from seed, and trees from seedlings, will be described in Chapter III.

19. *Concluding Remarks.*—Though the Bengal system of mulberry cultivation is very expensive, still it is possible to make a clear profit of Rs. 50 per bigha by rearing silkworms, following even this expensive system of planting. Silkworms reared on the proper system do not die off. What the right system of rearing silkworms is will be described in Chapter IV. Women can rear silkworms indoors; and silk-rearing may be therefore regarded as a most suitable employment for the poor but respectable women of this country who are not in the habit of going out of doors.

CHAPTER III.

PROPAGATION OF LARGE MULBERRY TREES.

20. *Advantage.*—In Chapter II it has been shown how it costs about Rs. 25 per annum to keep a bigha of Bengal mulberry in condition. If, however, mulberry plants are allowed to grow into trees, no permanent expense for cultivation is required. In other countries silkworms are reared on leaf gathered from trees. It is the excessive expenditure incurred in this country in the growing of mulberry that makes the

cultivator unable to sell his cocoons cheap to filatures. Owners of European filatures often incur loss and close their factories by paying excessive prices for cocoons and receiving small prices which prevail in Europe for Bengal raw silk. If they could purchase cocoons at the uniform rate of 8 annas per seer, they could work their filatures at a profit. If the growing of mulberry did not cost them so much, cultivators also could sell cocoons at 8 annas a seer, and still derive greater profit from sericulture than from ordinary agricultural pursuits. It is very important therefore to grow large mulberry trees in this country, such as exist in other countries. To grow trees, it is necessary to avoid stripping leaf for the first four or five years. If leaves are allowed to remain on trees and drop off when they get old of themselves, the plants will grow into serviceable trees in four or five years. For the peasantry it is not an easy matter to wait patiently for four or five years while the trees are getting ready. The interest and co-operation of zamindars are required in this matter. If each zamindar had only a bigha of nursery for mulberry and if he systematically distributed plants to his raiyats, it would be possible to plant as many as 6,000 mulberry trees every year in each estate. Zamindars can benefit their estates immensely by encouraging the propagation of mulberry trees. Large trees are not affected by weeds or the unfertility or exhaustion of the surface soil; while from the depths of the subsoil they bring up valuable manurial substances, which make silk-rearing by the aid of large trees a valuable help to ordinary agriculture which suffers so much in this country for want of manure. If mulberry trees are grown 100 to 150 feet apart, the crops grown in between the trees do not suffer to any great extent. In fact, where the soil and the air are naturally deficient in moisture (*e.g.*, in Manbhum, Birbhum, &c.), the planting of trees at distant intervals actually benefits the intervening crops instead of doing them harm. If the trees are planted too close, the land below becomes so shady that it is rendered unsuitable for the growth of ordinary agricultural crops. In such land it is possible, however, to grow *pippul* (*Piper longum*), turmeric, ginger, pineapple, ground-nut, and seedlings of betel-nut and cocoanut palms. If the trees are planted at a great distance apart, the intervening crops get the morning or the evening sun, which enables the plants to grow, and in some localities to grow well. When the trees are grown up, each is capable of producing one or two rupees worth of silk. Even if silkworms are not reared, the trees can be utilized with profit by rearing goats and cattle. In countries where silkworm-rearing is done, the mulberry tree is greatly valued. There people belonging to the upper classes obtain the equivalent of about Rs. 2 for every mulberry tree as an annual income without the slightest trouble, that is, when silkworm-rearers get a good crop of worms, their own stock of mulberry sometimes falls short, and they go to people who do not rear silkworms, but who possess mulberry trees, and pay them about Rs. 2 for the right of collecting leaf from each tree. Besides being a source of manure, silk-rearing gives other extra profits. The litter of silkworms is greedily eaten by cattle. The dried branches of mulberry, lopped off for gathering leaves from, may be used as fuel. Forty to fifty mulberry trees are an excellent property for a peasant family. They enable the peasant to grow about Rs. 100 worth of cocoons every year; and he is never in want of manure, of cattle-food, and of fuel. Bengal mulberry, if it is neglected for a time, is destroyed by cattle and gets overgrown with weeds, and it ceases to exist. Large mulberry trees suffer nothing from neglect.

21. *Gathering of Seed.*—Stray mulberry trees of various kinds are met with in most towns. Seed can be gathered from the ripe fruits from such trees. The seed of the *Morus Serrata* can be obtained from the Scotch missionaries of Kalimpong near Darjeeling in the month of April, when the fruit ripens. It may be useful for particular localities, where proper mulberry trees happen to exist, to know how seed is obtained for propagating large mulberry trees. Mulberry trees of various kinds are indigenous in the Himalayan and sub-Himalayan countries, and in some parts of Bihar, North-Western Provinces and the Punjab they may be seen in thousands. When the

fruits ripen and fall to the ground, they should be collected in the fresh state, and without losing time divested of stalks and put in a trough, where they are to be kneaded with both hands, and water poured on the mass. After stirring the mass in the water, the trough should be inclined and the supernatant liquid poured out. More water is to be put in the trough, the mass stirred again, and the supernatant liquid rejected. Thus treated for 10 or 12 times, nothing but loose and clean seed will be seen at the bottom of the trough, which can be overturned after the addition of some more water, and the seed collected on a piece of thin calico. The seed is then to be spread out thin on the calico and left to get dry in a place shaded from direct rays of the sun. The whole process, from the collecting of fruits to the drying of seed, should be done in the same day, or else, the seed getting fermented, its germinating capacity is lessened or lost. Dried in the direct rays of the sun, the mulberry seed also loses its power of germination.

22. *Sowing of Seed.*—When the seed has been gathered, and when the time for sowing arrives, some camphor-water should be got ready. About half an ounce of camphor may be powdered and loosely tied along with a pebble in a piece of thin calico and dipped in a bottle half filled with water. The bottle is to be stoppered, shaken up, and left for a day, when the camphor-water will be ready for use. The mulberry seed is to be put in camphor-water and left steeped in a stoppered bottle for two hours, and sown immediately afterwards in boxes containing sand and vegetable mould or very rich soil. Fresh natural manure should not be used. The boxes should be kept in verandahs. Sowing in boxes is not feasible when large quantities of seed have to be sown. Then the seed-bed is to be prepared, and the seed sown under cover, in the same way as these are done for cabbages and cauliflowers. Sown in boxes placed in verandahs, the sowing may take place in July; but sown in seed-beds, even under cover, it is not safe doing it before September, as the seed-bed may get under water during heavy rains, and insects may also attack the plants. Mulberry seed and seedlings are very much subject to the attacks of ants and other insects. To avoid harm from this source, one should use ashes, lime, rapedust, and white arsenic (*sankhya*)

in the proportion of $1:4:2:\frac{1}{400}$ as an insecticidal mixture, sprinkling this mixture on seed-beds immediately after sowing the seed. When the soil in the boxes or seed-beds gets too dry, water is to be sprinkled on it. The camphor-steep helps the free germination of the seed. The mulberry tree is usually propagated from cuttings, as the seed does not germinate well. Other vegetable seeds which do not germinate freely usually do so when they are sown after the camphor-water steep recommended for mulberry seed.

23. *The Nursery.*—If seed is sown in boxes in July, the seedlings will bear 4 to 6 leaves in August, when they are to be picked out carefully with roots and planted a cubit apart in a nursery. The nursery should be formed where there is no fear of the land getting deluged with water in the rainy season, where it can be constantly watched that weeds, cattle, or insect-pests may not damage the plants. It is also important that the nursery should be close to water, and that it should be exposed to the full rays of the sun. The method of cultivation required for a plot of Bengal mulberry is to be followed in the case of a nursery for propagating mulberry trees. In other words, the land is to be dug up with spades in the cold weather, ploughed twice in May after a shower of rain, ploughed again once a month during the following three months, ditched and fenced round in September, and after two or three ploughings and harrowings, the seedlings from boxes or beds are to be carefully taken out with roots and planted in the nursery at the distance of one cubit on each side. When the seedlings are transplanted only the two leaves at the tip should be left on each, the lower leaves being carefully picked out. This operation helps the vigorous growth of the plants. If it is intended to use the plants for rearing silkworms within 3 or 4 months, and to treat them like Bengal mulberry, 5 or 6 seedlings together may be planted a cubit apart, instead of single plants. This will result in thick little bushes being formed, which are to be cut away, if the Bengal system of cultivation is desired, when they are about 20 inches high. The shoots coming up afterwards may be utilized for rearing silkworms. In the nursery, however, where single plants are grown a cubit apart, they are never to be cut away, but left to grow tall. If they are not injured by goats or cattle they will grow straight

up. After the seedlings are planted in the nursery, the principal operation is occasional weeding. Watering is also required afterwards when the soil gets dry.

24. *Transplanting.*—If the seedlings are planted in September, and the nursery well cared for, the plants will attain a height of 9 to 12 feet by next August, when they are to be removed from the nursery and planted in open fields. Raiyats themselves can remove the plants carefully with roots from their zamindars' nurseries and plant them in their own fields 100 to 150 feet apart, each raiyat planting 40 or 50 mulberry trees. While transplanting them in this way, they should bear one thing in mind. All the side branches, leaves and buds, within 6 feet from the base of the plants, should be cut or picked off, and the branches beyond 6 feet in height should be stripped of all leaves except the growing tips. The plants are to be stuck in the soil with roots in this bald condition (Fig. 1). In transplanting trees the more of roots left and the less of leaves, the better it is for the future growth of the trees.

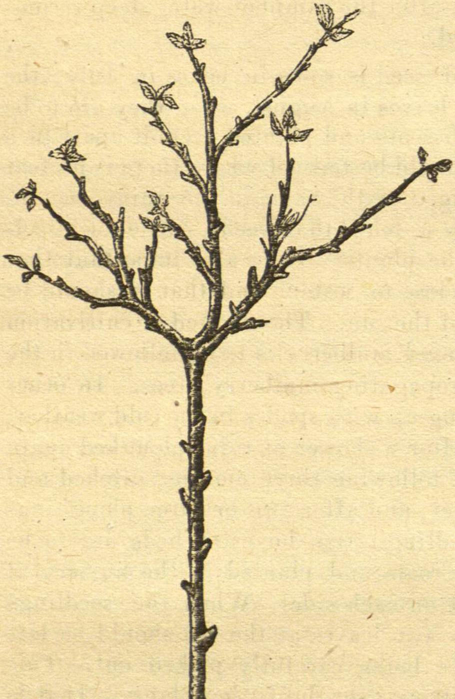


FIG. 1.—Mulberry tree ready for transplanting.

Planted in this way, in rainy weather they do not become faded in the least, and the buds left shoot forth with great vigour without loss of time. If leaves are left on the trees when transplanting them, some of them die, and those that survive take long in putting forth new shoots. When cultivators have planted the trees in their fields they have very little to do afterwards. In fact, it is not necessary even to protect them with gabions, unless goats and cattle prove very troublesome. If it is desired to save the expense of putting gabions, the trunks of the trees up to the height of 6 feet from their base may be smeared from time to time with cowdung or castor-oil, that goats may not get to know that the bark of the mulberry is not repulsive as food. All the buds of the trunk being picked out from the first, the growth of leaves will take place high up, beyond the reach of cattle, while within their reach there will be nothing but dung or castor-oil-smeared trunks. The soil of the nursery should be rich, and when the trees are transplanted to the fields of cultivators, rotten manure should be put in the holes dug for sticking the trees in. Ordinarily no watering or manuring will be required after the trees are once planted in the rainy season. Up to four years from the time of transplanting no branches should be lopped off the trees, nor leaf stripped. Thus propagated, the trees will yield an abundant supply of branches and leaves after four years, when silk-rearing can be commenced without spoiling the trees.

25. *Use of the Trees.*—As a rule, each Bengal cultivator has as much land as he can till with the help of a plough and a yoke of oxen—that is about 12 bighas or 4 acres. If he plants mulberry trees only at the boundaries of his fields at a distance of 60 or 70 feet, he can have about 50 mulberry trees round the 12 bighas of land. He can make more profit out of these 50 mulberry trees than by cultivating the 12 bighas; while the existence of these trees is no bar to his cultivating his land as usual. The special benefit of having these trees will be perceived when it is seen that all the work in rearing silk, from the gathering of leaf to the harvesting of the cocoons, can be

accomplished by his women folk, who do not give him much assistance in his ordinary agricultural pursuits carried on out of doors. If the trees are not allowed to grow tall, but always kept down to the "standard" height, women can gather leaf with the help of a little crook without being obliged to climb the trees. The reeling of silk out of cocoons can also be done by women. Owing to the prevalence of the zanana system in this country, there are not many industries which afford suitable employment for women. Such being the case, the propagation of large mulberry trees and the rearing of silkworms should be taught in this country in every province and district and village.

26. *Pruning of Trees.*—For the trunks of mulberry trees to steadily increase in girth, for the branches and leaves to grow luxuriantly, while at the same time for the leaf to be tripped from every branch by bending it from below, it is necessary to prune the trees in a special manner. For the first four years after transplanting them to the fields, all branches attaining a height of over 10 or 11 feet from the ground should be lowered and pruned up to this height, the pruning being done in December or January. In this way all the growth will take place between 6 to 11 feet from the ground. After four years, when silk-rearing will commence, the pruning is to be done every second year immediately after gathering the leaves for silkworms. Thus treated, the branches will always remain pliable, *i.e.*, capable of being bent from below. In places where people do not object to climbing trees, there is no necessity for keeping mulberry trees to the "standard" height. On the other hand, if mulberry trees are allowed to grow high, the timber will be worth a great deal more if any necessity should arise to cut down a tree.

27. *Expense and Outturn.*—The expense in connection with the formation of a nursery is about the same as that in connection with planting Bengal mulberry. In other words, the formation of a bigha of nursery costs about Rs. 40. To maintain the nursery permanently also costs about Rs. 25 per annum—that is what a bigha of Bengal mulberry costs to

maintain it permanently. If instead of distributing trees freely to raiyats a charge of 1 anna per every tree is made, the annual outturn by sale of plants may come to Rs. 400, as, planted a cubit apart, a bigha would hold 6,400 plants. If cultivators once get to appreciate the value of mulberry trees, they will not grudge paying 1 anna per tree after four years, when they begin using them for silk-rearing. Thus, zamindars maintaining a bigha of mulberry nursery for systematic distribution of grown-up plants to raiyats need not do so at any sacrifice to themselves.

CHAPTER IV.

REARING OF SILKWORMS.

28. *Varieties of Mulberry Silkworms.*—In Bengal there are five kinds of mulberry silkworms, called respectively (1) *Chhotapalu* or *Deshipalu;* (2) *Nistári*, *Chakrá*, *Canary*, or *Mádrásipalu;* (3) *Cheenápalu;* (4) *Bulupalu;* and (5) *Barapalu.* The *Cheenápalu*, the *Bulupalu*, and the *Barapalu* are reared chiefly in Midnapore. The *Barapalu* is also reared in very small quantities in Birbhum and Murshidabad. Ordinarily only one crop of *Barapalu* is obtainable during the year. Its cocoons are beautifully white, and larger in size than the cocoons of ordinary Bengal silkworms. In Midnapore the *Barapalu* spins cocoons of four different shades, viz., white, greenish white, salmon-coloured and bright yellow. The *Barapalu* silk is superior to all other kinds of Bengal silk; but the rearing of the *Barapalu* is not popular among silk-rearers, and the export of *Barapalu* silk has nearly died out. Most of the *Barapalu* silk, called *dhali* silk (white silk), that is still produced is utilized by native weavers for weaving high class fabrics. The main reason for the *Barapalu* being neglected is that cultivators are not in the habit of looking a year ahead of them. The moths of the *Barapalu* lay eggs in March, and these eggs hatch again in January. Our cultivators are naturally averse to keeping the eggs carefully preserved for ten months before recommencing the rearing of the worms in

January. They are quite agreeable about rearing them if they get hatched worms given to them every year in January. Indeed, there should be one or more establishments for preserving *Barapalu* eggs carefully throughout the year, hatching them at the right time, and distributing hatched worms to cocoon-rearers. In France and Italy there are many such establishments. The improvidence of our raiyats alone accounts for the neglect of a valuable class of silkworms because their eggs take ten months hatching; while they content themselves with rearing inferior classes of silkworms, because their eggs hatch within a week or a fortnight after they are laid. The silkworms of which the eggs hatch in 8 or 10 days can be reared 7 or 8 times successively during the year, and our cultivators are fond of doing the same kind of work throughout the year. If silkworms are reared month after month in a particular locality diseases are liable to break out, and a parasitic fly also gradually gets the upper hand. These multivoltine silkworms produce small cocoons, and the silk reeled out of such cocoons is inferior to that obtained from *Barapalu* or European cocoons.

29. *The Grainage.*—A number of *grainages* or establishments for the production of healthy silkworm eggs have been established in Bengal with Government aid. As cocoon-rearers will get to know more and more the work done in these establishments, they are likely to appreciate the importance of rearing the *Barapalu* and the European silkworms also. In these establishments all the seed used is selected with the help of the microscope, and only what is free from disease is reared from. The seed so selected is reared in localities where no silkworms from unselected seed are reared. Certain special methods are also followed in these *grainages* in rearing the silkworm. The cocoons obtained in them are seeded, and this seed used without selection also gives good result. The seed selected with a microscope and used in the *grainage* is called "Cellular Seed." The seed obtained from cocoons grown from "Cellular Seed" under certain favourable conditions of segregation and sanitary arrangements is called "Industrial Seed."

A person wishing to start a seed-rearing establishment must be prepared for selecting his seed every time with the help of a microscope before commencing rearing, *i.e.*, using "Cellular Seed" every time. He can sell the resulting crop for seed to others, and call it "Industrial Seed," or "Selected Seed No. 2." It is impossible to supply every cocoon-rearer with "Cellular Seed" or "Selected Seed No. 1," *i.e.*, seed that has gone through microscopic selection. In Part II of this book will be found a detailed account of microscopic selection of seed. Any one wishing to learn this method of selection can do so in about a month's time, if he is apprenticed in one of the *grainages* established with Government aid in Bengal. The seed, whether Cellular or Industrial, is rendered still purer by giving it a dip in a sulphate of copper bath. For washing eggs, rearing-rooms, and appliances used for rearing silkworms the sulphate of copper solution should be prepared by mixing together 1 part of sulphate of copper (the *tuntia* of the bazar) and 100 parts (in weight) of water.

30. *Disinfection of Appliances.*—Whether the seed is brought from one of the *grainages* spoken of, or whether it is brought from elsewhere, the same methods should be followed in rearing the worms. If rearing of silkworms has been done in the same room and with the same appliances within the past 12 months, half a seer of sulphate of copper should be powdered and mixed with about fifty seers of water, and the mixture used in rubbing or *leping* the rearing-room and its front part outside the room, a similar solution being also used for disinfecting rearing-trays and other appliances. The *chandrakies*, *i.e.*, the bamboo screens on which silkworms are made to spin their cocoons, should be deftly passed through a flame of fire, then dipped in a stream or tank, and while still wet, stored in the room which has just been *leped*. When all the appliances have been got ready, half a seer of sulphur should be powdered, put in a *handi* or earthen vessel, and the *handi* put on a slow fire. When the sulphur melts and catches fire of itself the *handi* should be taken inside the rearing room, and, while coming out of the room, all the doors and windows should be firmly

shut up. The room should be left shut up for about 12 hours. The fumes of sulphur kill germs of diseases that may have escaped the action of sulphate of copper. The eggs can be taken inside the room after it has been fumigated and thrown open. The eggs should be washed with sulphate of coper solution, dried immediately afterwards by keeping them exposed in an open but shady place, and then taken inside the disinfected room and placed on a tray already disinfected along with other appliances.

31. *Various Requisites*—(1) *Leaf*.—The mulberry leaf in stock, or which is obtainable during a period of one month, should be the guide of procuring the proper quantity of seed and other requisites. It is impossible to learn from a book the art of guessing rightly the amount of mulberry leaf in a field or on a tree. Experience is the only sure guide in this matter. If leaves from mulberry trees have to be used, the age and the size of a tree enable one to judge whether during the next month it will yield the total quantity of half a maund, or one maund, or two maunds of leaves. When trees are first used for rearing silkworms, *i.e.*, four or five years after they are planted, each yields less than half a maund of leaf. A *Morus Serrata* tree (which is the largest variety) yields as much as four maunds of leaf when it is ten years of age. If the Bengal system of cultivation is followed, the vigour of the plants, their height, and the area of the field are taken into consideration in judging the approximate quantity of leaf obtainable. If the area of the field is not known, and if means for measuring it exactly are not forthcoming, then the field should be paced along in slow steps, both lengthwise and breadthwise, the number of steps being counted each way. The two numbers should be multiplied and the product divided by 6,400. Each slow step being reckoned as a cubit, and 6,400 square cubits making a bigha, the quotient will give an approximate idea of the area in bighas, or fractions of a bigha. Whether the land is measured exactly or roughly in the way just described, the character of the plants, as observed by pacing the field up and down, ought to enable one to judge whether there are 2 maunds

of mulberry leaf per bigha, or 4 maunds, or 10 maunds, or 20 maunds, or 30 maunds. If the plants have attained an average height of only 9 inches, a whole bigha will yield only about 2 maunds of leaf. If they are about a cubit high, 6 maunds per bigha may be expected; but if the plants have grown taller than full-sized men, and if their growth is vigorous and luxuriant, 25 to 30 maunds of leaf may be looked for from a bigha. If the land is kept well cultivated, and if it is irrigated in December and in May, a crop of 20 maunds of mulberry may be expected in the November *bund*. of 9 maunds in the January *bund*, of 16 maunds in the March *bund*, of 10 maunds in the May *bund*, of 20 maunds in the July *bund*, of 25 maunds in the early September *bund*, or a total yield of 100 maunds per bigha. If there is a bigha of Bengal mulberry, or 15 large mulberry trees at hand, the rearing requisites should be procured on the basis of 30 maunds of mulberry leaf. From 30 maunds of mulberry leaf one can produce 60 seers of fresh cocoons. The list of rearing requisites described below refers to a maximum of 60 seers of cocoons, which is about the average quantity of cocoons reared in an important *bund* by each rearer. In those seasons (*bunds*) when 30 maunds of leaf cannot be expected from the bigha of mulberry, all the trays and spinning screens will not be required; or, if it is desired to use them all and get a full crop of 60 seers of cocoons, other mulberry leaf must be procured to meet the deficiency.

32. (2) *Rearing-rooms.*—Two rooms with mud walls are required. These should be used for sleeping and other domestic purposes as well as for silk-rearing. It is easy enough getting a crop of 60 seers of green cocoons from one room, but it is healthier to have it reared in two rooms. If the walls are not made of mud but of mats, there should be double matting with straw stuffed in between, or one side at least should be so well plastered over with mud and cowdung that cold or hot winds may not find free access into the room. A cultivator who possesses two dwelling-rooms can rear every *bund*, or six times a year, 1½ maunds of cocoons, *i.e.*, at least Rs. 30 worth of cocoons. But one cannot obtain 30 maunds

I G N.C.A. LIB.
86-3188
Deptt of Arts
12-12-86
GOVT. OF INDIA

of mulberry leaf every *bund* from 1 bigha of land. Because it is possible to get this maximum quantity of leaf once a year, it is necessary always to have all the arrangements for rearing 1½ maunds of cocoons. It is convenient, therefore, not to have a separate house made for rearing, but to keep the worms in the dwelling-rooms, in quantities large or small according to the supply of mulberry at hand at the time. If the rooms are used for domestic purposes also, it will not be possible to overcrowd them with the silkworms. The rooms should have one door and one or two ventilators--an arrangement commonly seen in most village houses. That the parasitic fly may not find access into the rooms, *chiks* or bamboo curtains should be hung in front of the doors and windows or ventilators. The *chiks* can remain drawn up early in the morning and again in the evening, when there is no fear of the fly getting inside the rearing-house. But so long as the sun is up the *chiks* should be down. In those *bunds* when the fly gives no trouble great precaution in this respect is not required. In those seasons when the parasitic fly proves troublsome the rearer should have shallow plates of clean water, to which a few drops of kerosine oil should be added, arranged outside the rearing-house over against the windows and ventilators. The fly will be found dropping into this water and getting drowned. When the wind is northerly, rearing of worms should be commenced in a room facing south, and when they require more space than is to be obtained in this room, they can be afterwards distributed into other rooms. When the wind is southerly, it is advisable to commence rearing in a room facing north. In the same way, rearing should be done as long as possible in a room facing west when the wind is easterly, and *vice versâ*. The stands on which the worms are kept should be so placed that draughts of air may not pass through them. In no season is direct entrance of currents of air into the rearing-house to be allowed, if it can be avoided.

33. (3) *Trays.*—To obtain 1½ maunds of green cocoons, it is necessary to have 40 large-sized trays ready. Each tray should be about 4 cubits long and 3 cubits wide; or, if they are

round, their diameter should be about 3½ cubits. Small trays are not desirable, as they involve greater labour in handling the worms. When the silkworms which are destined to make 1½maunds of cocoons first hatch out they occupy only half the space of a tray. After about 30 days the worms, gradually increasing in size, will occupy nearly 100 times the original space. During those 30 days the worms moult or change their skins four times. After each moult the worms require about three times the space formerly occupied by them. In other words, the worms which are kept on half a *dálá* (tray) when they first hatch out should be spread out on 1½ *dálá* after the first moult; after the second moult, they should be allowed 4½ *dálás;* after the third moult, 13 *dálás;* and after the fourth moult 40 *dálás*. Thus it is necessary from the very first to have 40 *dálás* ready. In the cold weather no harm will take place if the worms destined to make 1½ maunds of cocoons are kept on 30 *dálás* or even 20 *dálás;* but in the hot weather it is advisable to keep the worms sparse.

34. (*4*) *Eggs or Seed.*—When 30 maunds of mulberry leaf is at hand, seed should be procured for obtaining 1½ maunds of cocoons. If seed of the *Nistári* variety is obtained, it should be remembered that eggs laid by six moths only are likely to produce one seer of cocoons. If the *Chhotapalu* variety of silkworms are reared, it should be assumed that 10 layings of eggs are likely to produce a seer of cocoons. If European silkworm seed is procured, 3 layings should be calculated as likely to yield a seer of cocoons. For *Barapalu*, 4 layings should be calculated as likely to yield a seer of cocoons. A great deal more of produce may be obtained than what has been stated as likely to be obtained. In other words, *Nistári* moths may lay an average number of 450 eggs each, instead of 300 eggs. These 450 eggs may go to produce 400 cocoons, and these cocoons may be of such good quality that 1,200 of them may go to a seer. Thus calculated, 3 layings of *Nistári* eggs may produce a seer of cocoons. In actual practice, when a large quantity of silkworms are reared, excellent result is said to have been obtained when 5 or 6 layings

of *Nistári* eggs produce a seer of cocoons. Some eggs do not hatch, some are eaten up by spiders; some worms get devoured by lizards and rats, some ripe worms are carried away from *chandrakies* by birds, and others are killed by wasps. In this way, it is fair to calculate that 5 to 6 layings of *Nistári*, or 8 to 10 layings of *Chhotapalu*, are required to produce a seer of cocoons. In localities where mulberry leaf cannot be purchased, it is safer to work on a much lower calculation, or else it may so happen that for want of only a day's supply of leaf all the worms have to be sacrificed. Where reliance is placed only on 30 maunds of leaf procurable from 15 trees or a bigha of Bengal mulberry, only 100 layings of European silkworm eggs, or 150 layings of *Barapalu* eggs, or 250 layings of *Nistáripalu* eggs, or 400 layings of *Chhotapalu* eggs should be procured. If some mulberry leaf remains over when the rearing is completed no great harm is caused, but if it falls short at the end the loss is felt very keenly. Where mulberry leaf can be easily purchased, twice the quantity of seed just mentioned may be obtained without incurring much risk. On the Murshidabad side, if 500 layings of *Nistári* eggs or 800 layings of *Chhotapalu* eggs produce 1½ maunds of cocoons, satisfactory result is thought to have been obtained. Much better result than this is obtained from selected seed. If instead of buying eggs one chooses to buy seed-cocoons, or *sunch*, twice the number of cocoons of the layings recommended should be procured. In other words, where mulberry plants are not common, or where the silk-rearing industry does not exist, 500 *Nistári* cocoons should be used for seed in order to obtain 1½ maunds of fresh cocoons. It is possible to get 1½ maunds of cocoons from this quantity of seed, but only a maund is likely to be obtained.

35. (5) *Sulphate of Copper.*—For every crop, half a seer of sulphate of copper should be used. For washing the eggs very little of this substance is required. When a rearing is over, the room, trays, nets and other appliances should be washed with sulphate of copper before another rearing takes place. For all purposes the proportion of sulphate of copper and of water to be used is 1 : 100 in weight. When eggs are washed with sulphate of copper water, it is necessary to get them dry as soon as possible.

36. (6) *Sulphur.*—One seer of sulphur should be procured every *bund* before commencing rearing. If any disease breaks out the *dálás* are to be cleaned, the room *leped* or rubbed with sulphate of copper water, and sulphur burnt afterwards. When disease breaks out, and also at certain other times, sulphur should be burnt in the rearing-house. The method of burning sulphur on different occasions is described in different places in Part II of this book. When the rearing is finished, half a seer of sulphur is to be used in the manner prescribed in paragraph 30. In this way, if sulphur and sulphate of copper are used every *bund* in disinfecting the appliances, and the contrivance for killing flies automatically described above be adopted, silk-rearing may be done, *bund* after *bund*, with impunity, or else disease is sure to break out and cause more or less damage, or the worms may be spoilt by the parasitic fly.

37. (7) *Nets.*—For 40 *dálás* 80 pieces of netting, such as is used for catching small fish, should be procured. Each piece of net should be large enough to cover a *dálá*. There are three advantages in using nets:—First the *delitage*, *i.e.*, rejection of the litter every day, or every other day, is facilitated by the use of nets. If a piece of net is spread over the worms, and fresh leaf sprinkled over the net, the worms crawl on to the fresh leaf, leaving the litter behind underneath the net. After three feeds again, *i.e.*, on the next day, the top worms is taken up and placed on another *dálá*, and the *dálá* with the old litter is taken out and cleaned. The worms placed on another *dálá* already spoken of should have another piece of net spread over them and fresh leaf sprinkled over the net. After three feeds again, *i.e.*, on the next day, the top net with the worms on it is to be put on another *dálá*, and the *dálá* with the lower net and the old litter should be taken out of the room, and the net and the *dálá* shaken clear of all dirt. The net so cleaned can be again spread over the worms and fresh leaf sprinkled on it. In this way a couple of nets are required for each *dálá* of silkworms. The cleaning of worms should not be done inside the rearing-room, as dust is most injurious to silkworms, but in an ante-room, which may serve also as a further protection against the parasitic fly. Secondly, the use of nets facilitates the *thinning* of the worms, *i.e.*, when

worms appear too thick on a *dálá,* a net can be used in spreading them on to two *dálás.* The net is spread over the worms appearing too thick, and leaf sprinkled thick and fast over it. After waiting for about 5 minutes, that is when half the worms will appear to have come up to the top net, the net with these worms is to be taken up and placed on another *dálá.* In this way the worms of one *dálá* are easily distributed uniformly to two. While the worms are crawling up to the top net, instead of waiting doing nothing, one can go on cleaning or putting leaf on other trays. Thirdly, the use of nets also facilitates the separation of moulting worms from such as are late in moulting when they get disuniform. When worms are moulting they do not eat and they lie motionless. If leaf is put on moulting worms they get buried under it, and only those that are late in moulting come up to the top. Every day, at cleaning time, it should be observed, on removing the net, whether there are worms in the litter underneath. If there are many lying motionless in the litter, it should be inferred that these are moulting worms, and they should not be disturbed by *delitage,* the *dálá* being kept on a separate stand. The worms removed with the net and placed on another *dálá* are to be given fresh leaf, but without the intervention of a net. This *dálá* is also to be placed on the stand in which the other *dálá* is placed, but at a higher level. No feeding will probably be required for these *dálás* for a whole day. If the rearing-room is allowed to remain very cold, the worms late in moulting may require one or two feeds more before they go to moult. If on removing the net at the time of cleaning it is seen that very few worms have gone to moult in the litter below, these few worms may be picked up and put on the net with worms just removed, and another piece of net spread over the worms and feeding gone on with. Next day, at cleaning time, it will be seen, on removing the net, a great quantity of worms have gone to moult in the litter. The top net with the worms which are late in moulting should be removed to another tray, and leaf sprinkled lightly on it. Thus divided into two trays, the early worms should be kept at a lower level than the late worms on a *máchán,* or stand, reserved for moulting worms. Feeding should be suspended for 24 hours for both trays. If, however, the room be too cold, the worms go to moult and come out of it tardily and disuniformly. In such case the above instruction about suspending and recommencing giving of leaf should not be carried out. But the room should not be too cold, or if it is, it should be kept warm with fire, or no rearing should be done when the season is too cold. Unless it is too cold, it is very easy to manage the worms at moulting times with the help of nets. *The feeding should not be stopped until all the worms have gone to moult, and it should not be recommenced until all the worms have got well out of it.* These two rules are most essential. Another very important rule to be observed in rearing silkworms is that young worms should be kept very sparse from the beginning. If young worms are kept very thick, they make small cocoons even when they are kept thin afterwards and given plenty to eat. In fact, it is sometimes economical to keep big worms crowded; but it is impossible to get healthy results if these have been kept crowded when young.

38. (8) *Bonti.*—A *bonti* is a big knife, fixed on to a log of wood. It is required for chopping leaf very fine when the worms are small. The leaf thus chopped fine is sprinkled over young worms. As the worms get bigger and bigger, the leaf can be chopped less and less fine. After the second moult small branches of Bengal mulberry leaf may be put on the worms.

39. (9) *Máchán, khop, ghará or stand.*—For keeping 40 trays arranged properly, 4 *máchâns* or stands are required. On Murshidabad side these stands are called *gharás*, and on Malda side, *khops*. These *gharás* or *khops* are used for keeping 16 *dálás*, one above the other. It is not healthy keeping worms so crowded together, especially in the hot weather. It is best, therefore, to keep small quantities of worms in dwelling-rooms, the 40 trays being kept in four *máchâns* in two rooms. For each *máchán*, 4 upright posts made of thick bamboos, 20 cross-pieces made of slender bamboos, and 1 lb. of strong twine are required. The upright posts should be planted in the floor, and a device should be employed for keeping out rats in connection with these posts. In thatched houses rats may drop down on the *máchán* from the top, as well as climb up from the bottom. Rats may be avoided in this way. Eight earthenware cones for each stand, with orifices in the middle big

enough for the bamboo posts to go through should be got made by a potter. When planting a post, one of these cones should be so attached to it that it may rest about 9 inches from the ground, with its concave side downwards. A rat crawling up a post will be thrown back when it tries to get round the cone. For making the cones adhere firmly to the posts, it is necessary to use plugs of straw or jute. Instead of earthen vessels tin cones may be used. The upright posts having been planted, and cones being attached to them, the cross-bamboos are to be tied on to them with twine, and four more cones are to be attached to the top ends of the posts with their concave side upwards. A rat coming down from the top will descend on one of these conical vessels first. If it comes across some fried rice mixed up with white arsenic (*sankhya*) on the conical vessel where it alights, it will naturally eat this first and die. The width of the *mácháns* should be regulated by the size of the *dálás* and *chandrakies*, *i.e.*, these should easily go into *mácháns*. If the *máchâns* are made in pairs, or joined end to end, six upright posts only are required for two *máchâns*. For such *máchâns* the cross-pieces should be much longer and straight. Immediately underneath the lower cones a stickfast ought to be smeared round the post to keep off ants. The stickfast is made with *dhuna* (sal tree gum) and colza oil boiled together, say half a seer of oil and quarter of a seer of powdered *dhuna*. When this mixture begins to boil, a few drops of *akanda* (*Asclepias gigantea*), milk and a little water are put in it, and the stickfast is ready for use. The stickfast thus prepared does not dry up for a long time; still it is necessary to watch daily that the stickfast is continuing sticky.

40. (*10*) A *hook* for cutting mulberry stalks is also required.

41. *Gathering of Leaf.*—The leaf should be gathered in the morning and also in the evening, or in the evening only. The leaf so gathered will do for the night feed, the morning feed, and the midday feed. A day's supply of leaf should be always obtained in advance. If it becomes cloudy during the day, and if rain is apprehended in the evening, a day's supply of leaf should be got in at once. So long as there is dew on the leaves, or so long as they are wet after a shower of rain, they should not be gathered. If it rains continuously for 2 or 3

days and no respite is obtained for the leaves to get dry, they should be gathered in the wet state, brought indoors, spread out, dried by fanning, and then given to worms. Wet, fermented, muddy, or dusty leaf should never be given to worms. For determining the approximate quantity of leaf daily required for producing a crop of 1½ maunds of green cocoons, the following calculation should be resorted to. For getting 60 seers of cocoons, it is necessary to use 30 maunds of leaf altogether from the first to the last day. Of these 30 maunds, about 25 will be consumed by the worms at the last stage, *i.e.*, after the fourth moult, and only 5 maunds before the fourth moult. In other words, worms eat 5 times as much at the last stage as they eat in all the earlier stages put together. Before the first moult the daily consumption will be from ½ a seer to 1½ seers, *i.e.*, about 5 seers altogether. From the first moult to the second the daily consumption will increase from 1¾ seers to 2½ seers, *i.e.*, about 15 seers altogether. From the second to the third moult the daily consumption of leaf will increase from 3 seers to 8 seers, *i.e.*, about 45 seers altogether. From the third to the fourth moult the daily consumption increases from 10 to 25 seers, *i.e.*, about 135 seers altogether. After the fourth moult 1½ maunds to 6 maunds will be consumed daily until one or two worms ripen, when the consumption will again fall to about 2 maunds a day and less, *i.e.*, about 25 maunds altogether will be required at the last stage. Now $15 = 3 \times 5$, $45 = 3 \times 15$, $135 = 3 \times 45$, and $5 + 15 + 45 + 135 = 5$ maunds, and 5 maunds $\times 5 = 25$ maunds. Thus as the worms increase three times in size after every moult they require 3 times as much food, and at the last stage they require 5 times as much food as they ate during their previous existence.

42. *Feeding.*—Worms should be given leaf more and more mature as they grow in size. If mature leaf is given to young worms, and tender leaf when they get big, they take a form of disease called *rasá* or grasserie. If equally mature leaf is given to worms from the first to the last no harm is done, but it is essential that young worms should not get maturer leaf than what they get afterwards. Up to the last moult worms should be given, if convenient, 4 or 5 feeds a day; but at the last stage only 3 feeds. In dry weather 5 or 6 feeds a day, given to young worms, give healthier results.

43. (*11*) *The Chandraki.*—For producing 1½ maunds of cocoons 15 *chandrakies* (or bamboo screens with spiral ledges, also made of plaited strips of bamboo) are sufficient (Fig. 2).

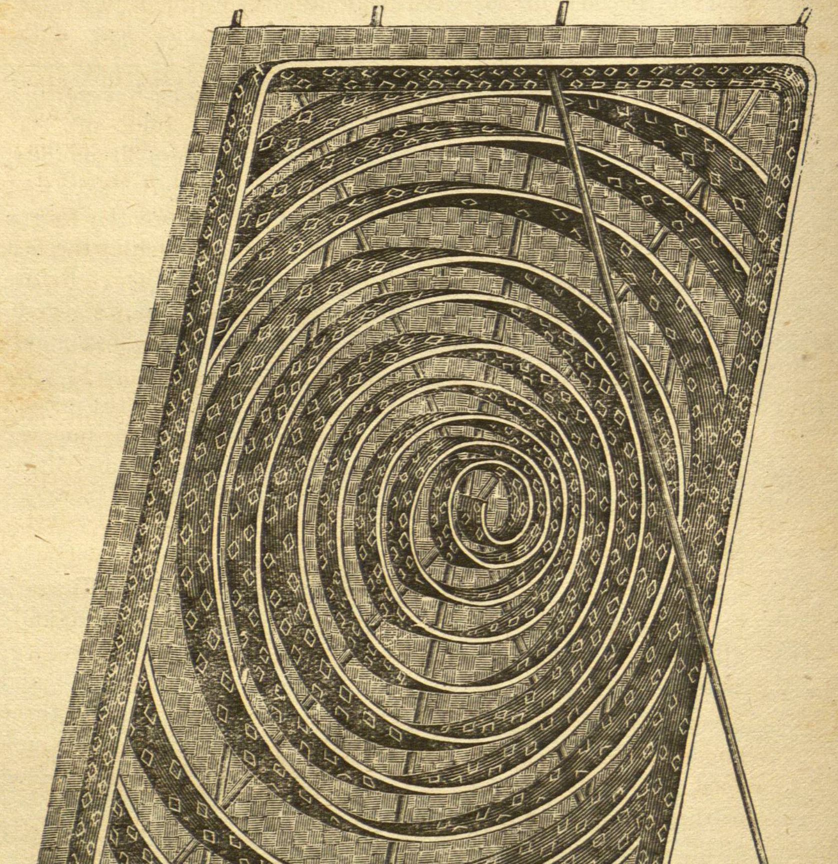


FIG. 2.—Chandraki or Spinning Screen.

Each *chandraki* answers for 3 seers of cocoons. If the cocoons are taken out on the third day it can be used again for putting in the worms ripening on the third or fourth day, to make a fresh lot of cocoons. If ripe worms are picked up from feeding trays and put on *chandrakies*, they make clean cocoons. But if *chandrakies* are not forthcoming, straw crumpled up and spread over an ordinary mat does as a fair substitute. Ants are easily avoided when *chandrakies* are used, as the legs on which they are made to rest may be smeared with a stickfast, or ashes put round them; but with ordinary mats such arrangements are not easily made. Strips of waste paper may be crumpled up and put inside a basket or cask in which ripe worms have been already put. The worms crawl up and make very fair cocoons amidst the strips of paper. In the case of European silkworms dry and bushy branches may be arranged on the feeding trays, to induce the ripe worms to mount on them and make cocoons.

44. (*12*) *An open shed* for keeping the *chandrakies* neatly arranged should also be provided. From the roof of this shed loops of strings are to remain suspended, in which the ends of the *chandrakies* are to be slung, so that they will remain hanging loosely abreast of one another. This arrangement prevents white-ants getting at them. The feeding trays should be kept arranged on the *máchâns*.

45. *Rearing.*—The eggs washed with sulphate of copper are to be placed on a *dálá* when dry. Eggs of European silkworms are usually obtained in a loose state. The eggs of *Barapalu* are usually deposited on pieces of calico, on which they are left to hatch. Eggs of the ordinary kinds of Bengal silkworms are deposited on *dálás* or sheets of paper, to which they remain adhering. After the pieces of calico, or *dálás*, or sheets of paper to which the eggs remain adhering are put in the sulphate of copper dip, and taken out immediately afterwards, they still remain adherent. The room in which the eggs are placed should not be too cold or too warm in temperature. The *Chhotapalu*, the *Nistári*, the *Cheená* and the *Bulu* varieties of silkworms do not suffer by excess of heat or

cold within certain limits. In other words, the heat or cold which prevails at different seasons in Lower Bengal does not affect the uniform hatching of these varieties of silkworms. In some years, however, the heat in April and May is so intense that eggs of these varieties also perish and do not hatch at all, or hatch very partially. If eggs are exposed to the direct rays of the sun, or if they get heated, they get pink coloured and they do not hatch completely. Intense cold also affects Bengal silkworm eggs similarly. For getting *Barapalu* or European silkworm eggs to hatch evenly after the cold season is over, it is necessary to keep the room where hatching is to take place uniformly warm day and night, or else they go on hatching for a long period. If these two varieties of silkworm eggs are kept in little calico bags, and the bags kept suspended with strings from the necks of persons who are to carry them about inside their clothes day and night during the period of incubation, the eggs will have a temperature almost uniform. Eggs so incubated hatch fairly well. To keep a room uniformly warm day and night is not feasible for most people; but to keep an ounce or so of eggs in a little bag inside one's clothes is not so very inconvenient. The inferior varieties of Bengal silkworms give no trouble whatever in hatching. There is another trouble about the hatching of European silkworm eggs; they come loose, and it is necessary to spread a piece of mosquito curtain net before putting leaf on the hatched-out worms. If this is not done, when the worms with the leaves are removed, unhatched eggs getting entangled with the leaves are also removed, which hatch a day or two afterwards, thus causing worms of different sizes to be mixed up in the same lot; which is a disadvantage.

46. When *Chhotapalu* or *Nistári* eggs hatch, leaves are chopped up very fine and spread over them without the intervention of a mosquito curtain net. The worms go on hatching out from early morning until afternoon. The leaf, therefore, is to be spread over them in the afternoon. Two or three hours afterwards the leaf with the worms is to be removed and put in a compact and circular mass, *i.e.*, the particles of leaf which were lying scattered over the eggs are to be collected into a fairly thick mass. On this some fresh

chopped-up leaf is to be sprinkled. About 9 o'clock in the evening some more leaf is to be sprinkled on it. If at this time it is seen that the worms are too thick they should be spread out, either with the help of a net, as described in paragraph 37, or with a feather if the quantity is small. The leaf given to these young worms should be tender and as fresh as possible. Next morning again leaf is to be put on the worms in the same way. Before giving the midday feed a piece of net should be spread on the worms and leaf sprinkled on it as before. Then leaf is to be sprinkled over the worms that have hatched on that day, and later on they are to be collected into another compact and circular mass (called "*chaki*") and placed on another *dálá*. This *dálá* is to be placed above the previous day's *dálá*. In other words, worms hatching out on the first day should be kept on the lowest shelf of the *máchán;* those hatching out next day are to be kept higher up; and those hatching out on the third day should be kept higher up still. In this way worms hatching out of a lot of eggs for the first three or four days only should be kept. Any straggling ones hatching out afterwards should not be kept, but burnt with fire. Eggs properly treated hatch out in two days, almost completely. The object of having early worms on the lowest shelf and the late ones higher up is to keep the latter in a higher temperature, the upper part of a room being warmer than the lower part. Late worms kept in a slightly warmer temperature gradually attain the same size as the early worms. In the same way worms that go to moult before their fellows should be separated by using the net and kept in a lower place on the *máchán*, while the worms that are tardy in moulting should be placed high up. The object of having all the worms of uniform growth is to prevent late worms being spoilt by flies and diseases, as these are more subject to their attack than early worms. Another way of getting worms to become uniform is to give the late ones an extra feed or two until they attain to the same stage as the earlier hatched worms. Ordinarily, feeding is to be done early in the morning, in the midday, and at 9 o'clock in the evening; cleaning should be done daily or every other day, before the midday feeding; and thinning out of worms when they appear too thick on any tray should be also done then.

Moulting worms should not be given leaf. To avoid mistake in this matter and consequent harm, moulting worms should be kept on one *máchán* and worms that require to be fed on another. The kind of net required for cleaning, &c., is indicated in Fig. 3.

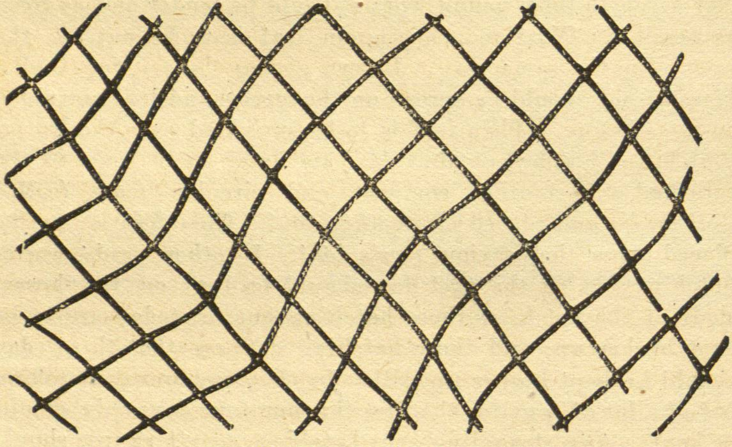


FIG 3.—Cleaning Net.

47. In the hot weather worms eat for 20 to 24 days before making cocoons. If young worms are fed 4 or 5 times a day, the spinning takes place within 18 or 20 days after hatching during the hot season. In the cold season worms eat leaf for 30 to 40 days before making cocoons. By keeping fire in the room they can be made to spin in 24 or 25 days, even in the cold season.

48. The cleaning and sweeping should be done so gently that these operations may not raise dust in the rearing-room. Instead of sweeping the room and the verandah in front, it is better to *lep* (= rub) them with sulphate of copper water, or with water to which a little lime has been added. Dust gives rise to a kind of disease called *kálshira* (flacherie). The harm from dust is corrected by the sulphate of copper or by lime. If the *dálás* are taken outside the rearing-room and cleaned, worms very rarely take flacherie. It is also advisable to have two calico bags full of lime dust ready at the time of cleaning, that dusting of lime may be done after removing a dead worm, when one is noticed.

49. When the worms ripen, *i.e.*, when they are ready to make cocoons and look translucent, they should be picked out from the feeding trays and put on *chandrakies*. To pick them up quick requires practice. All the operations connected with silk-rearing require practice. It is impossible to know the various operations connected with sericulture thoroughly simply by reading descriptions about them in a book.

50. Silkworms are subject to various kinds of diseases. It is impossible that these diseases should do any appreciable harm if rearing is done exactly in the manner recommended in this chapter. The diseases of silkworms are described in Part II of this book.

51. *Chandrakies* with ripe worms on them should be exposed to sun for an hour or two a day. The rays of the sun should fall in a slanting way on the worms, as direct rays hurt them and they may be killed by long exposure. When in sunlight worms fall readily to making cocoons. A cocoon is fully formed in two days in the hot weather, and in three to four days in the cold. The *chandrakies* with ripe worms on them should be put up facing downwards, *i.e.*, they should be so put up in a slanting way that the worms, instead of being directed skywards, should be directed groundwards. Kept in this position for three or four hours, the worms will not void their liquid excrements, and wet and spoil the cocoons spun on the *chandrakies*. After remaining three days on *chandrakies* the cocoons should be brought down carefully, and kept thinly spread on *dálás*. The cocoons reserved for seed should be kept apart, and the rest of the cocoons that are to be reeled off into silk should be exposed to the sun for three or four hours a day for three or four days successively. If this is not done, it will be difficult to avoid moths cutting out and spoiling the cocoons.

52. The cocoons reserved for seed should be very select. They should be kept strung up with thread, as in that case the moths come out clean and lay more eggs. The needle and thread should be passed carefully through the edges of the cocoons that chrysalids may not get hurt. There should be a concave earthen vessel (*gámlá*) kept immediately under the strings of cocoons. The grubs of the parasitic fly, if any happen to lurk inside the cocoons, dropping into this vessel and unable to get out, will be easily entrapped and killed.

The grubs that will be noticed in the *dálás* on which the cocoons meant for reeling are kept should be also sought out and killed. The silkworm remains in the chrysalis state inside the cocoon 8 or 9 days in the hot weather, and 15 to 20 days in the cold, and then comes out of the cocoon as a winged moth. The male and female moths are called "*Chakrá,*" "*Chokri.*" The moths begin cutting out of cocoons early in the morning, and are done cutting out for the day by noon. The male and female moths should be separated at about 2 or 3 P.M., and the females, which are fatter and quieter, should be kept for laying eggs, which they do, if strong, soon after they are separated. The laying of eggs is nearly finished the same evening. Very few eggs are laid by the moths on the second day. The moths cutting out of a lot of cocoons on the last day are mostly females. No harm takes place if some males of the preceding day are kept over for the last day's females.

53. *Disposal of Litter.*—The refuse leaf and the droppings of silkworms daily obtained after the midday cleaning should never be allowed to get dry. They should be kept stored in a pit. This pit should be as close to the cowshed as possible, as the liquid manure from the cowshed falling into the pit will prevent the litter from getting dry. If litter is allowed to get dry, dust rising from it may be carried about with air into rearing-houses, causing disease to silkworms. Silkworm litter is greedily eaten by cattle of all kinds. They can actually live by eating nothing else. The droppings of cattle fed on silkworm litter should be also stored in a pit. The droppings of silkworms are a most forcing manure. These should be carefully preserved in the manure pit; and when well rotted, it should be used as manure. Fresh droppings of silkworms or of cattle should never be applied to land.

54. *Reeling and Spinning of Silk.*—It is impossible, merely by reading a book, to learn the art of reeling silk thread out of cocoons after they are smothered in the sun and then boiled with water, or of spinning coarse silk used for weaving *matkás* from pierced cocoons, *i.e.*, cocoons out of which moths have come out. These processes are described in Part IV of this book.

PART II.

DISEASES OF SILKWORMS AND OF THE MULBERRY PLANT.

CHAPTER I.

General Cause of Diseases and General Remedies.

55. *Loss caused.*—One of the principal causes of the decline of the silk trade of this country is the prevalence of certain diseases among silkworms. On account of these the cocoon crop has come to be looked upon as the most uncertain of all agricultural crops. A man who rears silkworms four times a year usually loses two crops entirely, and the other two crops are only partially successful. About 60 per cent. of silkworms reared die immediately before making cocoons, *i.e.*, after eating the full quantity of mulberry leaf. For this reason, for the last 25 years, silk-rearers in every district of Bengal have been gradually giving up their ancestral craft and taking to ordinary agricultural pursuits. For want of a sufficient supply of cocoons European factors also, in nearly every district, have either restricted their operations or caused them to be abandoned entirely. Twenty-five years ago the Kumarkhali silk factory in Jessore was recognized as one of the principal factories in Bengal; but now no trace of silk industry exists in that district. In the districts of Bogra, Howrah, Hooghly, and 24-Parganas silkworm-rearing is still carried on in a number of villages; but the extent of the industry in these districts is not sufficiently wide at present to enable European factors to work in them. The manner in which mulberry cultivation is done in Bengal renders the land eventually unsuitable for rice, pulse and other ordinary crops, the level of the mulberry land being raised in time. Thus the decay of the silk industry has resulted in large tracts of land being left without use, in silk-filatures in large numbers being closed,

and hundreds upon hundreds of skilled labourers being employed as ordinary labourers, earning a bare means of existence.

56. *Remedy.*—Although the cocoon crop has come to be regarded in this country as a most uncertain crop, the labours of some of the best scientific men of the age have resulted in its coming to be recognized in Europe as a certain crop. To understand the nature of those diseases which have rendered the cocoon crop so uncertain, and the means whereby they may be kept in check or eradicated, is, therefore, of the greatest importance to those who are engaged in the silk-rearing industry in this country.

57. *Recentness of the Plague.*—The first question which may naturally arise in one's mind is: If the cocoon crop has always been regarded as an uncertain crop, that is, if in all ages silkworms have mostly perished after eating the full quantity of leaf and before making cocoons? This cannot be. As far as we can gather no one knew of the worst plague, called *katá* (= pebrine), in this country 25 years ago. Other diseases are mentioned in history, but pebrine being the chief disease, the cocoon crop in Bengal must have been a surer crop in days gone by when there was no pebrine.

58. *The Spread of the Plague.*—Pebrine was first noticed in epidemic form in France in 1849. Since then it has appeared in Italy, Spain, Portugal, Turkey, Turkistan, the Caucasus, Kashmir, China and Japan. When silkworms became all but extinct in Europe as a result of the plague, the industry was preserved by the importation of "seed" from Japan. Since, however, the discovery by the greatest of French *savants*, M. Pasteur, in 1866 of a remedy for withstanding the ravages of this plague, the importation of foreign seed has gradually gone on diminishing and the indigenous races of European silkworms have gone on improving.

59. *Susceptibility to Plague.*—That the plague has spread throughout the world during the last 50 years does not seem to be due to the spread of the germs connected with it from one country to another. It has been seen that when different

varieties of silkworms are reared in one small room, the *Chhotapalu* variety is more readily attacked by the plague than the *Nistári*, and the *Nistári* more readily than the *Barapalu.* There is thus a natural difference between different varieties of silkworms in the degree of susceptibility to the plague. In April and May 1892, 12 varieties of silkworms were reared in one small room at Kalimpong, in the Darjeeling district. Of these, 11 varieties were from seed known to be free from disease, and 1 variety was from diseased seed. Of these 12 varieties, all became more or less infected with the plague except 2, *viz.*, the *Attacus Ricini*, or castor-oil-plant-feeding silkworms, and the wild mulberry silkworms (*Theophila Huttoni*). It should not be assumed that the castor-oil-plant-feeding silkworm and the wild mulberry silkworm possess a natural immunity against this plague; for the former have been seen elsewhere falling a victim to this plague. Those *Attacus Ricini* silkworms that resisted the plague at Kalimpong were very wild in character, *i.e.*, of vagabond propensity, and very strong. These facts clearly indicate that wild or wild-charactered silkworms enjoy comparative immunity from the plague. It may be here objected that the Tusser silkworm has been also known to die wholesale from disease. But pebrine corpuscles have never been observed in the Tusser silkworms. Whenever a diseased Tusser silkworm has been subjected to microscopic observation, the only disease noticed has been grasserie. Grasserie is not associated with any minute vegetable parasite, such as pebrine, flacherie and muscardine are associated with. The diseases that are caused by such parasites are resisted by the vigour of health. Domestic animals possessing this vigour to a small degree are more subject to the attack of such parasites than wild animals. Domesticated silkworms, living in the confined atmosphere of the rearing-rooms and getting their food without trouble, lose this vigour of health. In the wild state they breathe pure air and move about in quest of food. Domesticated silkworms never require to move an inch. In respect of moving about and flying there is some difference to be observed among the domesticated silkworms also. Some *Attacus Ricini* caterpillars rove about in the room when they are hungry, and some *Bombyx mori* caterpillars do the same in search of convenient corners for making cocoons. In outward appearance some domesticated mulberry silkworms resemble wild mulberry silkworms very closely. In France there is a variety of silkworms called *Moricauds* (=Negroes). They are quite black and full of vigour. At Bournabat near Smyrna, in Asia Minor, Mr. Griffitt has a silkworm-seed-rearing establishment. The caterpillars reared in this establishment are striped like zebras. These also are said to be a vigorous and disease-resisting variety. In this country Mr. J. Cleghorn (of the Public Works Department) established a vigorous black race of silkworms by selecting out only the stray black caterpillars from among the *Barapalu*. Unfortunately, this valuable race has been allowed to die out; but it can no doubt be re-established by selection. Among *Nistári* worms also in the cold weather black caterpillars are occasionally come across. By carefully rearing these apart, it is also possible to establish a strong race. There is another way in which the native vitality of silkworms may be restored within certain limits; that is, by rearing them throughout the year in places where the temperature happens to be neither too hot nor too cold, *e.g.*, in the plains in the cold weather and in the hills in the hot weather.

60. *Exchange of Seed.*—It has been said that pebrine has been discovered among wild silkworms also. If this be a fact, it is useless attempting to resist the plague by improving the vigour of silkworms. If the improvement of the vigour of silkworms does not act as a power against the ravages of this plague, the only remedy known is the selection of seed, free from the germs associated with the plague, with the help of a microscope. But the fact of the discovery of the germs of pebrine among wild silkworms is extremely doubtful. It is, therefore, important to remember the suggestions regarding improvement of the native vigour of silkworms while adopting the system of microscopic selection of seed. To effect improvement in the natural vigour of silkworms, *exchange of*

seed is of the first importance. In the hot weather attempt should be made to get down seed from a hill station. In January one should try to secure seed from Midnapore or Madras, where the winter is very mild, if any good and strong varieties of silkworm are available in those places. In Midnapore the varieties of silkworms called *Cheená* and *Bulu*, which resemble the *Nistári*, have deep black marks on their bodies, and they seem more vigorous than the *Nistári* when they are reared in the northern districts. Benefit may be derived by rearing these occasionally as a substitute for the *Nistári*.

61. *Imitation of Nature.*—Attempts have been made to improve the domesticated races of silkworms by rearing them in the natural way: that is, by keeping them on trees day and night as Tusser silkworms are kept. No improvement has taken place from following this method. The domesticated silkworm is not capable of standing the heat of the sun, draughts of air, nocturnal chill and rain. Reared in the open, the silkworm is also subjected to the attacks of bats, birds, squirrels, rats and other pests. It is impossible to rear the *Chhotapalu* variety of silkworms on trees in the open. *Nistáris* reared in this way make a few small cocoons. Captain Hutton succeeded better with the *Barapalu* silkworm, rearing it in this way at Mussoorie.

62. *Methods to be adopted.*—It has been stated that domestication is at the root of all the silkworm epidemics. Besides this general cause of diseases, there are certain special causes which account for the specific development of diseases. These causes will be treated in connection with the several diseases under their proper heads. It is, however, vain to expect that silk-rearers generally will abandon their present methods in preference for others more rational, when they come to understand the nature of these diseases. They get excellent results by following existing methods when they happen to get good seed. They understand very well that it is heathier to have only 8 or 10 *dálás* on a stand instead of 16 or 17, and only 1½ to 2 *káhans* (1 *káhan*=1,280) of full-grown silkworms instead of 2 to 3 *káhans* in each *dálá;* but they will never

abandon their practices of having 16 or 17 *dálás* in each stand, one above another, and 2 to 3 *káhans* of worms in each *dálá*. Sometimes they have actually got perfect results keeping worms so thick in their rearing-houses. Instead of asking them to alter their ways it is much easier to organize a method of circulation of healthy seed, and effect the improvement of the silk industry in that way.

SUMMARY OF CHAPTER I.

1. Means have been discovered for avoiding every form of silkworm disease.

2. The general cause of disease is domestication.

3. Black coloured *Barapalu* worms, picked *Chakrá* (=with deep black spots on their bodies) *Nistáris*, and vigorous kinds of foreign silkworms should be reared for seed.

4. Exchange of seed (from a different climate or a different kind of soil) does good.

By the use of good seed good result is usually obtained by following those methods which are actually followed by good and experienced rearers, but for obtaining good seed it is necessary to follow certain new methods.

CHAPTER II.

USE OF THE MICROSCOPE.

63. *Methods to be adopted by the Seed-rearer.*—To obtain first class seed it is very important to follow exact scientific methods. If such methods are scrupulously followed, there is not the slightest doubt about good seed being obtained. The methods that will be described in this part of the book, though superfluous in most cases for ordinary cocoon-rearers, are

essential for rearing cocoons for seeds. Of these, the use of the microscope is of first importance. The different parts of this instrument (Fig. 4) will now be described.

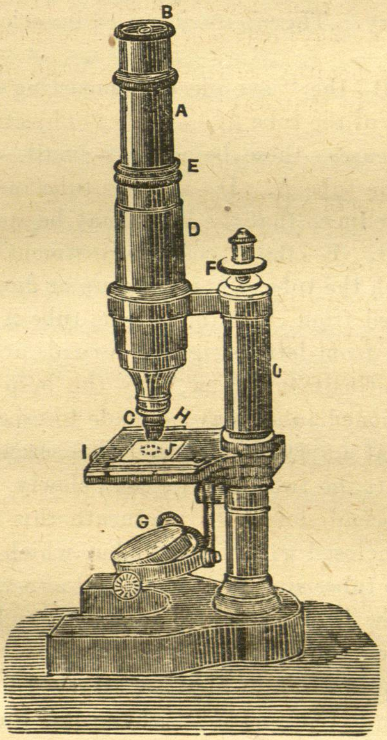


FIG. 4.—The Microscope.

64. *The Microscope.*—The microscope used in the selection of silkworm eggs is of simple construction; so much so, that when it gets out of order it can be put in repair by a village blacksmith. Though the construction is simple, the glasses used in it are very powerful. By their means very minute objects, magnified 500 times in each dimension, become easily visible. The minute objects which cause pebrine or flacherie are invisible to the naked eye; but with the help of this microscope they become easily visible. Microscopes of such

simple construction, but at the same time so powerful, are obtainable from M. N. Nachet et Fils, No. 17, Rue St. Severin, Paris, from Herr Carlo Reichert, of Vienna, and others. It costs about Rs. 70 or Rs. 80 to get one of these microscopes out to this country. The microscope used in sericulture has the following parts:—

A—a tube. B—the " eye-piece," consisting of two lenses, placed at the top of the tube A. C—the " objective," also consisting of two lenses—these being very small—screwed on to the bottom of the tube A. D—another tube inside which the tube A is so introduced that the latter may be made to work up or down at will. E—the " coarse-adjustment screw," with the help of which the tube A is worked up or down the tube D. This screw turned from right to left, the tube A descends at a quick pace, and from left to right it ascends at a quick pace. F—the " fine adjustment screw," by the help of which the two above-mentioned tubes may be made to ascend or descend simultaneously at a very slow pace. This screw being turned from right to left the two tubes descend slowly, and from left to right they ascend slowly. Underneath this screw there is a steel spring enclosed within a cylinder, which helps to raise or lower the two tubes simultaneously, but at a very slow pace. When the screw is turned from left to right, the spring becoming relaxed, stretches, carrying up along with it the cylinder and the two tubes which are attached to the cylinder. When the screw is turned from right to left the cylinder and the spring inside it descend, and the tubes being attached to the cylinder descend also. G—the mirror. The rays of the sun or of a lamp-light falling on the mirror become still brighter, being collected together into a smaller compass. To enable one to direct these collected rays towards the object examined the mirror can be turned in all directions. H—the " stage." The piece of glass on which the object to be examined is placed is made to rest on the stage. I—the " diaphragm." This is placed below the stage. The hole about an inch in diameter, which is in the middle of the stage, admits the light from the mirror to fall on the object examined.

By using the diaphragm this hole may be made smaller. If the collected rays of light from the mirror are admitted through a small aperture, the "field" of the microscope comes to view in well-defined outlines. Generally speaking, it is more convenient to admit light through the big hole of the stage, and not to use the diaphragm at all. While working the tubes downwards for examining an object it sometimes happens that the small lens at the lower end of the objective touches the fluid examined, and a blurred and indistinct view is obtained. When this happens, instead of disturbing the adjustment by raising the tubes too high and cleaning the lens of the objective, a finger with a piece of clean rag wrapped round it may be introduced from the bottom of the hole in the middle of the stage and the lens cleaned in this way. Another advantage of doing without the diaphragm is, it is less trouble getting light on the object through the big hole of the stage than through one of the small holes of the diaphragm. J—the slide. The slide is not a part of the microscope, but an ordinary piece of clean glass. The object to be examined is placed on this glass, and the glass introduced between the hole of the stage and the objective, the object resting immediately below the lens of the objective.

65. *Manipulation of the Microscope.*—It is convenient to work sitting on the floor in the Indian fashion when seed has to be examined with a microscope. In front there should be a glazed window. If the door or window in front of which examination is done is not fitted with glass, wind coming along with light may dry up the little fluid that is subjected to examination before the observation is finished. No distinct image is obtained when the fluid dries up. It is important, therefore, to have a glazed window in a seed-rearing establishment. Light should come from one direction only when microscopic work is done. The image or the field of the microscope will come out much more distinct if light comes from one direction only, instead of from all directions. The moths and eggs covered up separately with little earthen cups, and resting on a circular *dálá*, should be on the left-hand side of the person doing

examination of seed, the microscope in front of him, while on his right there should be some small pieces of thick waste paper, some slides, *i.e.*, pieces of ordinary clean glass, a vessel containing sulphate of copper water and another containing plain water, and a pencil. Nothing else is required for microscopic examination of seed. With a good, steady light it is quite convenient to work at night with the microscope.

66. First of all the mirror, the lens at the bottom of the objective, and the two lenses of the eye-piece should be cleaned with a clean piece of rag. If the neck has to be bent too low in placing an eye over the eye-piece, and if this posture seems inconvenient, the microscope may be made to rest on a small box. When seated comfortably, the person doing the selection is to take up a moth between the folds of a small piece of paper, give it a good squeeze, and take a thin particle of fluid out of the moth on a slide and place the slide on the stage. Then the mirror is to be turned about while placing an eye on the eye-piece until a light field is observed. Then the tube A is to be lowered with the help of the coarse-adjustment screw very carefully until the object to be examined seems to be coming to view. The lowering of the tube is to be done very very steadily, that its lower end, *i.e.*, the objective, may not touch the slide. Then the mirror is to be turned about again, the eye still placed on the eye-piece until the brightest light is obtained. After the object has become faintly visible by working the coarse-adjustment screw, as has been already mentioned, the fine-adjustment screw is to be given two or three turns from left to right. If the object does not become clearly visible after this, then the same screw is to be turned carefully from right to left, placing the eye on the eye-piece all the time, until the object becomes clearly visible. If the eye is not placed all the time on the eye-piece and careful watch kept, the object examined may pass out of sight without being noticed, and a few turns more of the screw from right to left may result not only in the lens of the objective touching the fluid examined, but also in the slide getting smashed under the pressure of the objective. A slide getting smashed in this way may spoil the lens of the objective either by causing cracks

on it, or dislocating it, or by actually breaking it to pieces. This lens is the costliest part of the microscope. The coarse and the fine-adjustment screws should therefore both be used with very great care. The less the fine-adjustment screw is used, the better it is. The tubes can be lowered or raised by means of the coarse-adjustment screw only, and there should not be much occasion to use the fine screw. The fine screw used continually, the spring inside the cylinder gets spoilt in time.

67. In examining the moths the earthen cups are to be taken up one after another, the moths got hold of with pieces of thick paper held between the thumb and the index finger of the left hand, in which state they are to be rubbed. By the intervention of the thick pieces of paper, the fluid contents of the moths will not come in contact with the fingers. All the time the examination is done one ought to be careful that this fluid does not come in contact with the fingers. After the rubbing, a slide held in the right hand should be rubbed on the fluid exuding from the moth held in the left hand. If the moth is too dry, *i.e.*, if the fluid does not get laid on the slide in a thin film, then a drop of water taken from the vessel kept for this purpose with the little finger of the right hand is to be put on the moth without touching it, and the slide again rubbed on the moth. In this way a thin film can be always obtained on the slide. If the fluid on the slide is too thick the field of vision will be very indistinct. If the objective touches the fluid on the slide, on account of careless manipulation, then the fine-adjustment screw is to be given two or three turns from left to right, the slide to be taken out, and the lens of the objective cleaned by introducing a finger with a clean piece of cloth wrapped round it through the hole of the stage. Then the slide is to be placed at one edge of the stage, and moved on to the middle of the stage, bringing the film of fluid immediately under the objective. After each moth has been examined a note should be made with pencil close to the eggs laid by that moth, indicating whether the moth was found diseased or free from disease. If this note is not made

each time, one may forget which layings have been examined before and which is at present under examination. After each examination the fine screw is to be given a turn or two from left to right, and the slide taken out at a level with the stage, that it may not touch the objective. The same slide can be used again and again for examining other moths. By careful manipulation, a line of the film caused by rubbing the slide against one moth will not touch its neighbouring line, and 8 or 10 moths can be examined on the same slide, making disarranging of focus unnecessary for a long while. When a slide is used up, it should be thrown into the vessel containing sulphate of copper solution. The moths also after examination should be either thrown into this vessel, or put on a large sheet of paper, in which all the used-up moths can be folded up after the examination is over and burnt with fire. Those layings of eggs which are marked " diseased " during examination are to be cut out of the sheets of paper or calico on which eggs are laid, and burnt. The spot on which the examination is done is to be smeared with sulphate of copper water; and the seeds of eggs containing the layings found free from disease are also to be dipped in sulphate of copper, exposed in a shady place, and dried. Before taking these sheets of eggs into the rearing-room it should be disinfected with sulphate of copper wash and sulphur fumes, with the *dálás* and *chandrakies* stored in it. This disinfection must be finished before the hatching of the eggs takes place. It has been already said that the slides are to be put in a vessel containing sulphate of copper water. After each day's examination these slides are to be washed with plain water, wiped dry, and folded up separately in strips of paper, so that one slide may not remain touching another and running the chance of getting cracked.

68. *The European Method of Manipulation.*—In Europe little pestles and mortars are used for pounding up moths for examination, but these are so costly that it is not possible to introduce their use in the sericulture of this country. In Europe cover-glasses are also used to cover the film of liquid examined. There are three advantages in using cover-glasses :

(1) the image seen is more distinct; (2) the fluid examined does not dry up so quick; and (3) the lens of the objective does not get to touch the fluid. By careful manipulation, one should never have occasion to use cover-glasses in examining moths. These are so thin and fragile and they cost so much in this country, that their use cannot be recommended in sericulture. The method of examination of moths recommended in this chapter, though crude, will be found suitable and efficient.

SUMMARY OF CHAPTER II.

1. The new methods to be followed in rearing silkworms for seed are chiefly connected with the use of the microscope. Microscopic selection has for its object the eradication of pebrine, which is the disease *par excellence* of silkworms.

2. The method of manipulating the microscope for selection of seed is very simple, and professional silk-rearers can learn it easily after a few days' instruction.

CHAPTER III.

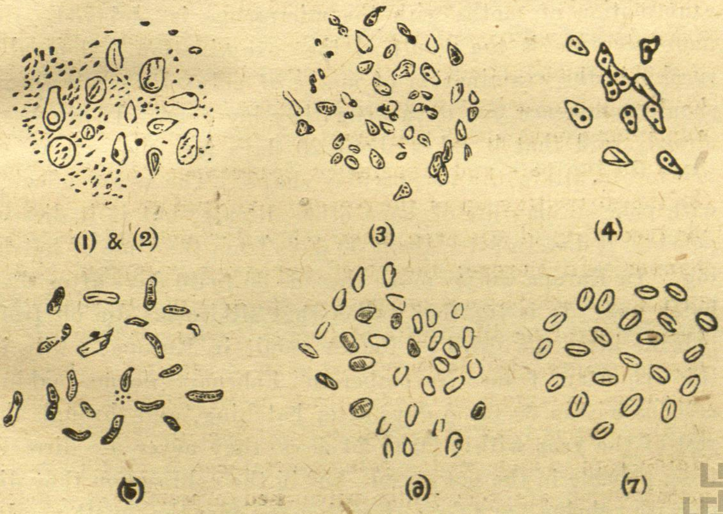
KATA OR PEBRINE.

69. *Diseases enumerated.*—The following are the diseases, abnormalities, and pests of the silkworm and of the mulberry plant which prevail in Bengal:—(1) *Katá (Pebrine)*, (2) *Chuná-Kété* or *Chhit (Muscardine)*, (3) *Rasá (Grasserie)*, (4) *Kálshirá (Flacherie)*, (5) *Láli, Rangi* or *Kurkuttè (Court)*, (6) the fly parasite, (7) the Dermestes beetle which makes holes in cocoons and also eats up silkworm, called *Shorè-poká* and *Kánkutur*, (8) *Gájlá-koá* (Satinè Cocoon), (9) *Génthé-koá* (Double Cocoon), (10) ants, spiders, rats, lizards, wasps, and crickets, (11) the disease of the mulberry called *Tukrá-lágá* or *Konkrá-dhará*, (12) the attack of the mulberry plant by

aphides (*Naichá-lágá* or *Doyè-lágá*). Of all these, *Katá* does the most damage. This chapter will be devoted to the consideration of this disease only.

70. *Cause and Symptoms of Katá.*—*Katá* or pebrine is a disease natural to the domesticated silkworm. It is in fact the disease *par excellence* of the domesticated silkworm. Other diseases arise from neglect or ignorance of management, or they may break out on account of pebrine lying latent among the silkworms. In every country the chief direct cause of failure of cocoon crops has been pebrine; but it is also the indirect cause of other silkworm diseases. When the germ causing this disease was first discovered by Guerin Menville in 1849, he identified it as the cause of *muscardine*, and he asserted that it was the germ which gave rise to *muscardine* that also caused the other forms of silkworm diseases. It was by the researches of M. Pasteur in 1865 and 1866 that the nature of pebrine as a specific disease became ascertained, and it was also determined that the germ already discovered was the cause of this disease. That the germs causing pebrine are different from the spores of *muscardine* and that the former cause one form of disease only, have been established by M. Pasteur. The naked-eye symptoms of this disease are not exactly the same in Europe and in Bengal. In Bengal this disease is identified by the following symptoms:—(1) The unexpected death of numerous worms about that 30th day from the time of hatching; (2) the pale and translucent appearance of the worms; (3) the shrivelling up of the worms into smaller size; and (4) the inequality of size even when rearing is done in the proper manner. In Europe, the chief naked-eye symptom of this disease is black patches or spots on the skin of the silkworms. These, appearing like dusts of pepper strewn on the worms, have given rise to the European name,—pebrine. The chief naked-eye symptom of this disease in Bengal, *viz.* paleness of the worms, has given rise to the Bengali name *Katá* or *Máthá-katá*, which means *pale* or *pale head*. In Europe the moths which are very badly pebrinised present lead-coloured patches on their bodies. This symptom also is not seen in

Bengal. But neither the peppery appearance nor the leaden patches are an invariable sign, nor even the usual sign, of the disease in Europe. The microscopic appearance of the disease is exactly the same in both countries. This is a certain indication that the two diseases are identical. The germs of pebrine passing from one form to another become gradually increased in number. The full development in form takes place in about 20 days, and the full numerical development in about 30. When the two diseases, pebrine and flacherie, subsist together, the full development in the form of the germ takes place only in 10 or 11 days. The germs of pebrine assume the following seven shapes in course of their development:—(1) minute dots or granules, often surrounded by bright circles; (2) amæboid spheres; (3) dumb-bell-shaped bodies or bodies of the shape of the figure 8; (4) pear-shaped bodies; (5) objects like full-formed pebrine corpuscles, but longer and broader; (6) objects like pebrine corpuscles in shape and size, but not so bright, nor possessing median lines; (7) the full-formed pebrine corpuscles. These are egg-shaped and bright, and each presents a straight line in the middle (Fig. 5).


(1) & (2) (3) (4)

(5) (6) (7)

FIG. 5.—Development of Pebrine Corpuscles.

71. *Diagnosis of the Disease.*—When moths die and get dried up afterwards, then the only form in which the germ of pebrine, if any is present, occurs in it, is the fully developed corpuscular form, *i.e.*, form No. 7. None of the developing forms are seen when a dead and dry moth is examined. A full-formed corpuscle may be also seen in the egg or the caterpillar stage, but the developing forms are more common in the earlier life of the silkworms. A caterpillar may be recognized as a pebrinised one even by its naked-eye appearance, and yet on microscopic examination of a little fluid taken from it, not a single full-formed corpuscle may be noticed. No conclusion can be drawn if one of the developing forms is noticed under the microscope. There are various other bodies which resemble one or other of these developing forms, but there is nothing exactly like a full-formed pebrine corpuscle. If one of these is noticed in examining a moth, then only should the specimen be put down as being certainly affected with the disease pebrine. In rearing silkworms for seed, however, it is safest to reject suspicious specimens also.

72. *Attack and Gradual Development.*—The longer the examination of moths with the microscope is delayed, the more accurate is the result of the examination. Generally speaking, the examination of moths of polyvoltine silkworms should commence five days after they lay eggs. It has been already said that it takes about 20 days for the germs of pebrine to attain the corpuscular shape. The worm affected with pebrine may die of some other disease, but if it dies of pebrine, it does so after about 30 days from the time of hatching. In Europe worms make cocoons 35 to 40 days after they hatch out. It is for this reason that silkworms die off from pebrine after the third or fourth moult in Europe; while in this country from November to February worms making cocoons within 30 to 35 days after hatching, and through the rest of the year within 20 to 24 days, they never die directly from pebrine in the hot season, but in the cold season they die off with pebrine 3 or 4 days after they get over the fourth moult, or even on the very last day when spinning should take place.

Worms dying suddenly in large numbers about the 30th day, one should conclude there was pebrine in the seed; in other words, that the loss is due to bad seed. If the seed is free from the germs of pebrine, the worms obtained from it may afterwards get infected with pebrine in various ways: (1) the dust of the rearing-room may be full of the germs of pebrine, and by their means the disease may break out; (2) mulberry fields being manured with the litter and droppings of silkworms, the leaf from such fields may have germs of pebrine on it, and silkworms eating it may get the disease; (3) in a village where one man has microscopically selected or naturally healthy seed, and hundreds use pebrinised seed, germs of pebrine may be carried along with the air into the rearing-house where pure seed is used, and infect the worms in it; (4) in the same *dálá* there may be some worms from eggs which had the germs of pebrine in them, and others from eggs free from pebrine. The latter may be infected by contact with the former. Silkworms which have had the germs of pebrine from the egg stage die in about 30 days from the time of spinning, whether in the caterpillar stage, or inside cocoons in the chrysalis stage, or (rarely) in the moth stage. Silkworms which contract the disease some day or other when eating leaf on the trays usually die after making cocoons and laying eggs in the moth stage, *i.e.*, 30 days after the infection happens to take place, when pebrine attains the maximum development. If a silkworm gets inoculated with a germ of pebrine the day before it is ripe for making cocoons, and if it is examined afterwards in the moth stage on the 5th day, the germ gets only 14 days to develop itself. Unless pebrine is associated with flacherie, corpusculation does not take place in 14 days, and the moth may be passed as free from disease, though full of pebrine. Of course, it is not necessary that worms should get infected at the very last. There is chance of infection taking place from the day the worms hatch out to the day they cease eating just before making their cocoons; only the chance is greater when worms begin to die off from pebrine at the last stage. In other words, if there are late worms that are healthy in one house, and if the worms in other houses in the same village die off from pebrine, these late worms are likely to be infected more or less by germs being carried about with air. Roughly speaking, however, microscopic selection is always beneficial, in spite of the liability to error in the hot season. In the cold season moths cut out of cocoons about 15 days after the cocoons are formed; so that, examination of moths taking place 5 days afterwards, disease will be detected even when infection takes place immediately before the worms ripen, because the corpuscular stage will have been attained, the development of the germs having gone on for 20 days from the eve of spinning to the day of microscopic selection. Examination conducted in the cold weather is, therefore, not liable to error if it is properly conducted. In Europe microscopic examination commences after the moths are nearly a month old, *i.e.*, when they are quite dead and dry, water being added to the moths when pounding them up for examination. In Bengal eggs usually hatch within 8 to 15 days after they are deposited, and it is impossible on this account to postpone the examination of moths for a month. If the examination commences on the 5th day, it will be found that most of the moths are yet alive and full of liquid matter. It is therefore not as a rule necessary to add water to the moths in getting a little fluid on the slide for examination. If the worms are healthy and if they are well fed the moths from them live for 10 to 15 days; so if healthy and well-selected seed-cocoons are chosen, the examination of moths in this country gives less trouble, *i.e.*, the moths being still alive and full of liquid, a good squeeze gives matter adapted for microscopic examination without the addition of water.

73. *Application of Pasteur's System.*—If there is only one man possessing the knowledge of microscopic selection of seed, and if there is only one microscope used in an establishment, it is possible even then to rear every *bund* 10 to 20 maunds of cocoons from selected seed. To do this it is necessary to have 400 to 500 female moths covered up daily with earthen cups for five days successively. The sheets of paper on which the

moths are kept covered up should be marked with the dates of their emergence. The examination of the moths should be done in the order of their emergence signified by the dates. In this way 200 to 250 moths can be examined daily for 10 days successively, making the total 2,000 to 2,500 every *bund*. Thus a large quantity of silkworms may be reared from examined seed without examining more than 250 moths a day and any that is less than 5 days old. One precaution, however, is necessary if this method is followed. As the worms hatch out for 5 to 7 days successively when this method is followed, the rearing of the different days' lots should take place in different rooms, and it should be also seen that none of these lots are later than the rest of the worms in the same village. Late worms suffer more from disease and from the attack of the parasitic fly. The full-formed germs of pebrine remain alive for nearly 7 months, while those in the developing stages of growth lose their vitality within a few hours. In live eggs of European silkworms or of the *Barapalu* the germs of pebrine remain alive as long as the eggs do, and 7 months longer, although the egg stage of these varieties may be prolonged up to 18 months. Remaining in a live state inside living eggs, the germs are reproduced annually in these annual silkworms. The germs of pebrine which exist in dead moths, in smothered cocoons, or in the dust of the rearing-room cannot do any harm after 7 months. In Europe, in Kashmir, in the Punjab, in China, in Japan, and in other countries where silk-rearing is done only once a year no possibility of loss from pebrine exists where "Cellular Seed" is used. In Bengal nowhere is a rest of 7 months allowed to rearing operations. It is therefore possible in Bengal, even when "Cellular Seed" is used, to lose silkworms from pebrine contracted by infection arising from old cocoons, dust of rearing-rooms, or old moths.

74. *Destruction of old Germs.*—The full-formed pebrine corpuscle is a heavy body, and it cannot come floating in the air from a long distance. If the old germs of pebrine in the immediate neighbourhood of the rearing-house and also inside

it can be destroyed before rearing is commenced, *i.e.*, if all possibility of immediate contagion from old moths, old cocoons, and dust connected with rearing operations can be avoided, one can rear silkworms time after time with success, and produce good seed also, by the use of selected seed. There prevails a very good custom in the silk-rearing villages of Bengal. Before rearing commences, the pierced cocoons are taken out of the room, and the room and trays are rubbed all over with a mixture of cowdung and earth, and the *chandrakies* are passed lightly through a flame of fire. This results in the old germs of pebrine, that is, the germs of the previous rearing, getting laid and entangled with the paste, unable to rise and do injury to silkworms; and the germs adhering to the *chandrakies* get killed with fire. It is safer still to kill the germs by using sulphate of copper for washing the room, *dálás, chandrakies* and nets, to burn all the old moths, to give all the litter to cattle, and to keep the cattledung pitted for a year. The litter is often a source of infection. In the removing and storing of litter great precaution should be used. In some villages it is allowed to be devoured by cattle as soon as it is brought out of the rearing-room. This practice does no harm if the solid and the liquid manures are afterwards collected and rotted in a pit before applying them to land. This rotting for a year does away with all the harm of the specific germs of silkworm diseases. The burning of litter has been recommended by some. This would no doubt destroy the germs of diseases most effectually, but it also means wasting of valuable manure. Good manures are such a rarity in this country that it is not at all advisable to destroy silkworm-litter. The precautions of storing it in a pit and rotting it are, of course, very important.

75. *Special difficulties in dealing with Pebrine in Bengal.*—(1) In Europe and elsewhere, where only one crop of silkworms is taken during the year, it is comparatively an easy matter resisting pebrine. (2) In Europe there are regular establishments for the microscopic selection of eggs, as this work can go on there for nearly 10 months. In Bengal eggs hatching in 8 to 15 days, very little time is obtained for

selection. (3) There is another reason which makes it difficult to deal with pebrine in Bengal. Here pebrine may be due either to bad seed or to infection; in Europe there is no fear from infection. If selected seed is used in Europe, one never loses his crop from pebrine, as the germs of pebrine in the previous year's moths, cocoons, and dust lose their vitality and become inocuous before the next year's rearing commences. Bengal, however, enjoys one advantage. In Europe, if a sample of seed is 50 or 60 per cent. pebrinised, it is sure to fail by worms dying off from pebrine, the reason being that it takes longer than 30 days for the worms in Europe to make cocoons. In this country it is easy to get the worms to spin cocoons in less than 30 days even in the cold weather, and in the hot weather they sometimes spin only after 18 or 20 days from the time of hatching. For this reason it is often seen in Bengal that seed showing 80 to 90 per cent. of pebrine on microscopic examination yields a fair crop of cocoons. There is, of course, some difference to be recognized among different lots of seed in the *intensity* of pebrine. If in the 80 or 90 per cent. of moths examined, each shows hundreds of corpuscles, the eggs laid by these are sure to fail; but of the 80 or 90 per cent. of moths, if the majority show only 1 to 4 corpuscles under the microscope, the eggs laid by them may yield a fair crop. But when such a large proportion of the moths shows pebrine corpuscles, the result can never be depended on; that is, if the eggs from those are used without selection, some rearings may succeed fairly well; others may fail entirely. The worms dying (when such seed is used) may die directly from pebrine, or they may die from some other disease. Pebrine inhering in seed gives it weakness and proneness to disease, any form of which may kill the worms. If 30 days are allowed to pass before cocooning takes place, the death of worms takes place directly from pebrine, and the external symptoms of pebrine are obvious. That the use of pebrinised seed often gives very fair result in this country is not to be taken to imply that pebrine is not so destructive to Bengal silkworms. It is important to recognize the first place of pebrine among all the diseases of silkworms. Although it appears in its own proper garb only in the cold weather, it is at the root of the destruction of silkworms at all seasons, whether the disease which actually does the work of destruction be *muscardine*, *grasserie*, *flacherie* or *court*. If pebrine is eradicated, other diseases also remain checked. Microscopic selection of seed, though primarily intended to check pebrine alone, will thus be found useful in arresting other diseases also. Pebrinised silkworms take *muscardine*, *flacherie*, *grasserie* and *court* much more readily than silkworms free from pebrine. The establishment of *grainages* is thus an indirect means of checking *all kinds* of silkworm diseases.

76. *Necessity for repeating Microscopic work.*—If pebrine is eradicated from a lot of silkworms, it should not be imagined that the eradication has been done once for all. Pebrine is a disease natural to the domesticated silkworms. No one can say how or when or whence a germ of pebrine finds access among a lot of perfectly healthy silkworms; but it does. That worms perfectly free from pebrine are liable to get this disease makes it absolutely necessary for seed-rearing establishments to repeat microscopic selection before every rearing. Sometimes it will be seen that the examination of 200 moths does not bring out a single specimen of pebrine. There is a great temptation, when this happens, to assume the rest of the seed to be free from disease and to rear it all without further selection. This should never be done in a seed-rearing establishment. Every time the microscopic examination should be gone through patiently and scrupulously. It is possible to get 10 or 12 good crops successively after one selection only, but if the moths are examined afterwards, it will be seen they have become full of pebrine somehow or other. Another characteristic of pebrine is that it never diminishes in quantity, but it steadily goes on increasing. If a sample of seed shows 5 per cent. of pebrine, and if it is used in an unselected state, the proportion of pebrine in the seed at the next generation is sure to be more than 5 per cent., probably 10 to 12 per cent. If this seed is again used without selection, the seed at the next generation is sure to show more than 10 or 12 per cent. of pebrine, probably about 20 per cent. In this way the increase will go on to 30 per cent., 40 per cent., 70 per cent., and finally to 100 per cent., and

when the proportion has become so exaggerated, it will be seen that worms will die off from pebrine. No other silkworm disease presents this characteristic. Worms showing *mucardine, court, grasserie* or *flacherie* may be used for seed, and at the next generation the worms may or may not show the disease which appeared at the last generation.

77. *General Cause of Pebrine.*—When animals or plants are reared in an unnatural way for our convenience, they become liable to certain diseases. Pebrine is a disease of this class. As examples the following may be cited:—the potato blight; tuberculosis among short-horn cows yielding large quantities of milk; consumption among men living in crowded towns; the drying up or rotting of mulberry trees grown from cuttings (to be described in Chapter IX), etc.

78. *Intensity of Disease.*—If a pebrinised moth lays 300 eggs, it is not to be supposed that every one of these 300 eggs has inherited germs of disease. If, on examining the moth, it is seen that there are thousands of corpuscles in it, most of the 300 eggs will show corpuscles. If, however, the examination shows one or two corpuscles only in the field of the microscope, probably none of the 300 eggs has inherited a corpuscle, or only one or two have. It is therefore unnecessary to waste a great deal of time in looking for signs of disease under the microscope. But one fact should be borne in mind; the corpuscles are heavy bodies that remain sunk in the fluid examined. It is therefore important to give the fine-adjustment screw a turn to the left and right even when the field has come to view, to examine every layer of the fluid. If no corpuscles are noticed even at the lowest stratum, the laying of eggs should be passed as healthy. It is not necessary to move about the slide to examine several fields before deciding, but one or two fields should be thoroughly looked into, and even if one of the developing forms of pebrine is suspected, the specimen should be rejected.

79. *The Germ of Pebrine, and how it multiplies.*—What the germ of pebrine is has not been exactly ascertained. There is difference of opinion among *savants* even on the question whether it belongs to the vegetable kingdom or to the animal kingdom. How the germ exactly multiplies is also a matter much debated about—(1) Whether the long bodies [Fig. 5 *(5)*]

become divided up into two or more corpuscles; or (2) whether the smaller end of the germ when it appears pear-shaped becomes severed away, forming a separate corpuscle; or (3) whether the minute granules seen inside a full-formed corpuscle come out of a gaping end and become nucleated into separate corpuscles is not certainly known. These three processes of multiplication may be called fission, gemmation, and granulation, and probably multiplication takes place by all the three processes.

80. *Isolation of the Rearing-house.*—It has been said that the germ of pebrine in one or other of the developing stages is a short-lived organism, and that in its full-formed stage it is a long-lived organism, *i.e.*, able to retain its vitality for 7 months. It has been also said that in the caterpillar condition of the silkworm, the germ occurs chiefly in one or other of the developing forms. If, therefore, *chandrakies*, cocoons, and moths are not kept in the rearing-room, the dust of the room will not contain many full-formed germs of pebrine. The few that may happen to exist get so firmly adherent to the floor or the *dálás* by the cowdung paste, that they cannot as a rule do harm to silkworms. The corpuscles of pebrine are to be found chiefly in cocoons and moths. It is for this reason advisable to remove the *chandrakies* with ripe worms to some distance from the rearing-room. The emergence of the moths from cocoons, the microscopic selection of seed, and the storing of cocoons also should not be done in the rearing room. The storing of cocoons for seeding or reeling, of *chandrakies*, and of moths for selection can be all done in the same room without any harm. There is no such fear of infection from reeled silk and filature "waste" as there is from whole cocoons and pierced cocoons. It is necessary to steam and boil cocoons before they are reeled. All germs of disease, whether of pebrine, or of *muscardine*, or of *flacherie*, lose their vitality when boiled for 5 to 10 minutes. That is why no harm can take place by silk or "waste" being stored in the rearing-room, or the chrysalides that comes from filature basins being used as manure for land. But it should be remembered that a rearing-house too close to a filature suffers greatly from diseases and the parasitic fly, as a great deal of fresh cocoons being imported into a filature, the air in its immediate vicinity

must be full of the germs of silkworm diseases, and there is also a great accumulation of flies.

81. *Examination of Male Moths unnecessary.*—Male moths do not require to be examined in the selection of seed, as these have no power to transmit the germs of pebrine to the eggs. It is the female moth alone that can transmit this disease to the next brood of silkworms.

82. *The Seeding-room.*—A description of the seed-room will not be out of place at the conclusion of this chapter. This room should not be the same as the rearing-room. The room where selection of seed takes place should have a glazed window in it, and there should be some means of closing this room fast. All cocoons, whether for seed or for filature use, may be spread out on *dálás* in this same room. When only cocoons for filature use are left in this room, it should be kept so tightly shut up that air may not find easy entrance into, or egress from, it. It is only a masonry-built room that can be kept so well shut up in such a room, if cocoons are stored, and for every 20 maunds of cocoons if a pound of carbon bisulphide be kept in it in an open vessel, rats and other vermin will be effectually prevented. Carbon bisulphide can be used in such a room in another way: if for want of sun difficulty is found in killing cocoons, carbon bisulphide can be put on a shallow vessel (a plate for instance), the doors and windows firmly shut, and the live cocoons left inside. Next day it will be seen the chrysalides have all died. To kill chrysalides a pound of carbon bisulphide should be used for every 4 maunds of fresh cocoons. As well shut-up masonry-built rooms are not easily available in villages, cocoons can be killed in *jálás* or *matkás* (huge jars), or in mud granaries called *kuthis.* The carbon bisulphide is to be put on a dish placed at the bottom of the *jálá* or *kuthi*, a basket put over the dish as a covering, and the *jálá* or *kuthi* filled up with cocoons, and immediately afterwards its mouth sealed with cowdung paste. In this way, also, it will be seen after six or seven hours that the chrysalides have all died. In a seed-rearing establishment it is very important to have this means ready at hand for killing cocoons. Opportunity should be given to the very last day for cocoons to be bought up for seed. Any remaining over may then be killed by adopting the means just described. In a seed-rearing establishment seeding should

be done in the manner described below. (1) The cocoons that are seeded for microscopic examination should be kept hung up in strings (Fig. 6). So strung up, moths come out of them

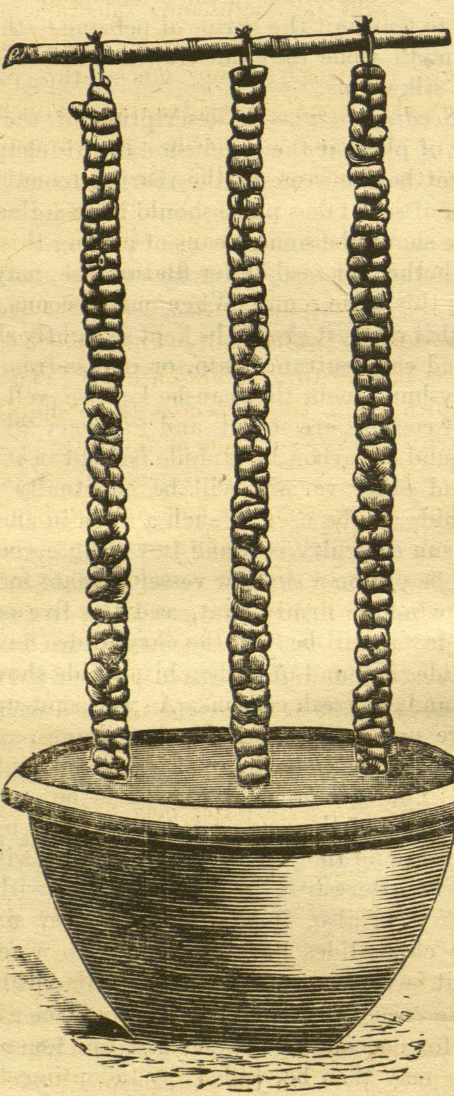


FIG. 6.—Stringing of Cocoons for Seeding.

more easily. Both ends of the cocoons being free, they do not have to waste their energy in struggling their way out, and they are able to lay more eggs in consequence. As a great deal of labour is spent in microscopic selection of seed, the labour comes to greater advantage when moths lay a larger quantity of eggs. In seed-rearing houses this plan should always be followed. Some other advantages also are derived from this plan of stringing up cocoons: the chrysalides inside the cocoons getting purer air produce stronger moths. A concave vessel, *e.g.*, the *gámlá* in which sulphate of copper solution is made, should be put under the strings of cocoons to allow the maggots of the parasitic fly to drop into it and of their being easily caught and killed. (2) The cocoons that are meant to be seeded "industrially" need not be strung up, but they may be laid in thin layers on *dálás*. That rats and ants may not do harm to these cocoons there should be the same arrangements in the seed-room as there are in the rearing room. Ants are to be avoided by smearing the posts of the *mácháns* on which the cocoons are kept arranged in *dálás* with a non-drying paste made by boiling *dhuna* (resin) and colza oil, and adding a few drops of *akanda* (*calotropis gigantea*), milk, and water while removing the boiling mixture from fire. Rats can be avoided by having earthen or tin cones fixed to the posts of the *mácháns* about 9 inches above ground. These cones may be fixed firmly to the posts by the use of a paste made of cowdung and earth, and with their bases turned upwards or downwards. If they are placed with their bases upwards, instead of a stickfast, phenyle water may be used for preventing ants. Phenyle water used in rearing or seeding-rooms has a tendency to check diseases, and it also acts as a deodorant. As rats may come down from the top also to the *dálás* where cocoons are kept, the cones should be fixed to the top part of the posts also, and white arsenic mixed with fried rice kept on them. If, instead of bamboo *mácháns*, chains are used for keeping the *dálás* suspended on them, no possibility will exist of rats or ants getting on to the *dálás* from below. Taking everything into consideration, however, bamboo *máchâns* are preferable for village use, as chains can be used in this way only in substantial *pucka* houses.

83. *Cocoons to be used in Seed-rearing Establishments.*—The cocoons used in a seed-rearing establishment should not be ordinary village seed cocoons, but such as are produced from microscopically selected seed; otherwise the proportion of seed that may have to be rejected in examination in the establishment is likely to be very great, and the labour spent in examination wasted. But this also should be borne in mind, that if 99 layings of eggs have to be rejected out of 100 on account of pebrine, the one laying free from pebrine will give good result, though it comes from a naturally weaker stock. The cocoons used in a seed-rearing establishment should, if possible, come from a stock *naturally free from pebrine,* and they should be also rich in silk. If even by using "Cellular" seed one gets *flacherie, grasserie* or *court* by some cause or other among his worms, cocoons from these worms should not, as a rule, be used in a seed-rearing establishment. That these three diseases will be noticed in an exaggerated degree in the next generation is not at all certain, but their existence should be taken as an indication of natural weakness.

84. *Cellular and Industrial Seed.*—In seed-rearing establishments two kinds of seed should be kept—(1) "Cellular," (2) "Industrial." From "Cellular" seed pebrine has been altogether eliminated by microscopic selection. Industrial seed is obtained from cocoons reared by using cellular seed. If there be less than 10 per cent. of pebrinised moths in a sample, the eggs laid by them also produce very good cocoons. This unexamined seed, which is the result of cellular seed, should be used by rearers generally, and it is this which may be called "Selected Seed No. 2." When seed selection goes on in an establishment, it comes to be known in the course of the selection whether there is more or less than 10 per cent. of pebrine in the crop which is intended to be sold to other rearers in an unexamined state. If less than 10 per cent. is noticed, the seed can be sold without any hesitation as "Selected Seed No. 2" at a fairly high price. If more than 10 per cent. of

pebrine is noticed, all the late cocoons of the establishment. *i.e.*, those out of which moths have not emerged up to the day of examination) should be smothered. The late cocoons always show a higher percentage of pebrine. If the moths of the first day's examination show more than 10 per cent. of pebrine, the late cocoons sold for seed to other cocoon-rearers are likely to give unsatisfactory results and cause loss. If rearing is done from microscopically selected seed, and if the rearing-room and appliances are properly disinfected before commencing rearing, the resulting crop should never show more than 10 per cent. of pebrine, and by careful work it will never become necessary to kill the late cocoons. It is advisable to sell the early cocoons also after cutting open a few chrysalides and examining them for pebrine. If the examination of chrysalides shows more than 5 per cent. of pebrinised specimens, it should be taken for granted that the moths when examined on the 5th or 6th day will show more than 10 per cent. of pebrinised specimens. If a seed-rearer allows bad seed to be sold out of his establishment even once, his reputation may be lost for ever. The seed-rearer should therefore always examine a few chrysalides or moths before selling his seed-cocoons or eggs.

85. *Seed-rearing arrangements.*—The female moths should be put in cellules, *i.e.*, under little earthen cups and on sheets of paper. The microscopic examination should commence 5 days after this. The method of examination has been described in Chapter II. It is only necessary to notice whether there are any full-formed corpuscles in the field of the microscope examined. The germs of *flacherie*, the crystals of *grasserie*, and spores of *muscardine* do not need to be looked for. The full-formed corpuscle of pebrine is so easily detected that microscopic selection will be found a very easy matter. After one has attained sufficient practice one should be able to examine 300 moths per day and select as much seed as will yield a maund of green cocoons. If one is careful about weeding out specimens showing *flacherie* or the doubtful stages of pebrine, one cannot examine more than 200 moths per day. The following calculation will show that a single seed-rearing establishment, where only one microscope is used, may benefit the

cocoon-rearing cultivators of a whole district. One microscope will enable a person to examine every *bund* 2,000 moths, *i.e.*, moths emerging for 5 days successively and examination going on for 10 days successively and in the hot weather; and moths emerging for 2 days successively and examination going on for 10 days in the cold weather. If 10 per cent. are rejected in the examination, 1,800 layings of eggs will be selected out practically free from pebrine. Each laying of eggs should produce about 300 cocoons, *i.e.*, 1,800 × 300 seed-cocoons may be produced at a time if one microscope only is used. If each cocoon-rearer buys 1,800 cocoons (about 1½ seers) for seed, 300 of them can be supplied with seed from one seed-rearing establishment. If work is conducted on proper methods in this establishment, the 300 rearers using this seed and following certain simple printed instructions issued with the seed from the seed-rearing establishment may get such beautiful results that others will eagerly buy up their crops again for seed. If the 300 rearers supply seed, each to 100 other rearers, 30,000 persons will be supplied with industrially good seed directly or indirectly from one establishment only. The Census Report of 1891 gives 85,000 as the number of cocoon-rearers in Bengal. In any case, it is certain there are not more than 30,000 cocoon-rearers in any one district. Thus if even one seed-rearing house can be established in each silk district, the cocoon-rearers of the whole district can be benefited, provided that silk produced in it is readily used by cultivators. This calculation will enable one to judge how easily the silk industry of Bengal can be improved by making arrangements for the microscopic examination of seed with a view to eliminate pebrine. In practice, of course, it is difficult to produce in one establishment seed required for 300 cocoon-rearers, and to dispose of the whole of the produce for seed. But it is not difficult to produce in an ordinary village cocoon-rearing house seed-cocoons for 100 rearers, and if the cocoons are really healthy, to dispose of at least a quarter of the produce for seed. Eight or ten seed-rearing nurseries can thus meet the demands of a whole district.

SUMMARY OF CHAPTER III.

1. In Bengal pebrine is outwardly visible only in the cold season. In other seasons it remains latent, but it induces other diseases.

2. Seed free from pebrine usually produces a crop free from other diseases also.

3. Ripe or full-formed germs of pebrine magnified 600 times appear like sesamum seed. It takes 10 to 20 days for the germ to ripen. If *flacherie* and pebrine occur together, the ripe stage is reached in only about 10 days. It is not possible absolutely to identify the disease even with a microscope when the germs occur in unripe or developing stages only. Microscopic selection of seed should therefore be deferred for at least 5 days from the time the eggs are laid. If this is done, the germ will get about 13 days to develop in the hot weather and about 20 days in the cold weather. The examination conducted even after 5 days in the hot weather is liable to error. In the cold weather no error should take place. For practical purposes seed selection, with a view to detection of full-formed corpuscles only, will be found a sufficient method for keeping all silkworm epidemics in check even in the hot weather.

4. Pebrine is not caused by bad seed only. The germs of this disease may exist in the rearing-house, in the trays used, in the spinning-mats, in the yard in front of the house, in pierced cocoons, in the litter, and in the mulberry land manured with silkworm litter. Worms reared from perfectly pure seed may get infected afterwards with pebrine, the germs finding access into their bodies somehow or other. It is

therefore very necessary that seed after examination should be dipped in a sulphate of copper bath, and the rooms, *dálás*, &c., washed with sulphate of copper before rearing commences. The *chandrakies* should be scorched in a flame of fire before the eggs hatch, and they should be also washed with sulphate of copper, taken into the rearing-room, and fumigated with sulphur along with other appliances. Nets and eggs should not be fumigated with sulphur. Nets should be washed in sulphate of copper water, and then in plain water. Exposed to sulphur fumes nets rot away within a year or two. Washed in sulphate of copper alone, nets also get worn out too quickly. Sheets of eggs showing blue colouration after the sulphate of copper bath should be washed afterwards in plain water. But if the strength of the sulphate of copper solution be 1 : 200, subsequent washing in plain water involving detachment of eggs will not be found necessary.

5. Refuse leaf and droppings should be daily taken out of the rearing-room, put in a pit, and rotted for at least 7 months before they are applied to land as manure. If they are given to cattle as fodder, the dung of the cattle should be rotted for 7 or 8 months before it is used as manure.

6. Full-formed pebrine corpuscles in a loose (disembodied) state remain alive for nearly 7 months. The germs of pebrine in one of the developing stages remain alive for only a few hours if they exist outside the bodies of live silkworms. Whether in the corpuscular stage or in the developing stage, the germ of pebrine remains alive inside a live egg or insect all

the time, however long the egg or the insect remains alive. If eggs remain in an unhatched state for 18 months, the germs of pebrine will keep alive inside the eggs through those 18 months, and after hatching takes place go on multiplying for 30 days both in the caterpillar and chrysalis.

7. European silkworm seed and *Barapalu* seed can be selected for a period of 10 months. It is useful, therefore, to keep seeds of these varieties of silkworms in seed-rearing establishments.

8. Early and late worms should never be kept in the same room. Rearing should never be done in a room where cocoons, whole or pierced, are stored.

9. By the use of one microscope two men working five or six hours a day can select sufficient seed for 10 to 20 maunds of cocoons per *bund*, *i.e.*, 10 maunds in the hot season and 20 in the cold.

10. If worms from pebrinised seed can be made to spin cocoons within 25 days after hatching, they may yield a fair crop. But in a seed-rearing establishment unexamined seed should never be used.

11. The seed-rearing establishment should be isolated from silk-rearing villages and filatures as much as possible.

12. The room for keeping *chandrakies* and cocoons and for examining moths with the microscope may be the same room, but it should be different from those in which silkworm rearing is done. Full-formed corpuscles may abound in *chandrakies*, chrysalides, and moths.

13. If rearing-rooms and *dálás* are rubbed with cowdung and mud, germs of diseases get agglutinated

with this paste, and being unable to get loose cannot do harm. If some germicidal substance, such as sulphate of copper (*tuntia*), sulphate of iron (*hirakas*), or alum (*phitkari*), is powdered and mixed up with the cowdung paste, the germs get killed also. Of these, sulphate of copper is the best substance to use, the strength employed being 1 : 100 to 1 : 300 according to the exigencies of the case.

14. In seed-rearing establishments the cocoons remaining unsold for seed to the last day should be killed with carbon bisulphide.

15. Seed-cocoons being kept strung up, the moths come out healthier and lay more eggs.

CHAPTER IV.

CHUNÁ-KÉTE, CHHIT, OR MUSCARDINE.

86. *Nature of the Disease.*—Next to pebrine, muscardine does the greatest amount of harm to Bengal silkworms. In Europe flacherie is considered as the most dreadful disease next to pebrine; but in this country there are not the same reasons for fearing flacherie. Muscardine is a disease caused by a mould or minute fungus. As mould of a certain species appears on shoes in the rainy season, so mould of another species appears on the bodies of silkworms. There are two varieties of this mould which give rise to muscardine. One is called *Botrytis Bassiana* and the other *Botrytis Tenella*. Both varieties of mould attack silkworms in the same manner. The spore or seed of the mould comes to rest on the body of a silkworm by some chance. When the silkworm is in a moulting condition, *i.e.*, when it remains motionless, the spore gets the opportunity for striking root. The roots penetrate deep into the skin. These microscopic roots branch out and gradually occupy the whole body of the silkworm. Some of these branches coming out into the surface fructify. These fruits

burst, and thousands of white-coloured spores come out of them and envelop the body of the silkworm. At this time the worm looks like a bit of lime-stick (*chuná kâti*). The spores, roots, and fruits spoken of can be distinguished only with the help of a microscope (Fig. 7). The white powdery substance seen on the surface of the body of the silkworm consists of spores of the fungus. One silkworm dying of muscardine, thousands of these spores get loose, each capable of settling on a moulting silkworm and killing it afterwards. From the day a spore settles on a silkworm to the day of its death there may intervene four to ten days. It has been already said that it is in the moulting periods the disease gets the best chance of taking root. It is for this reason that when one finds a number of dead worms

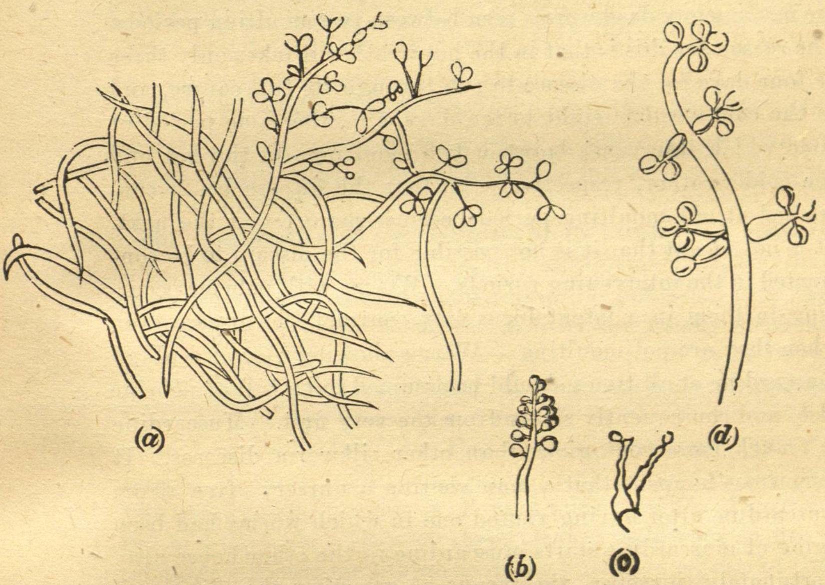


FIG. 7.—Muscardine Fungus.
× 500

(*a*) Hyphæ with spores ; (*b*) end of an old branch which is producing spores by abjunction, and is thickly covered with spores, the youngest of which are terminal ; (*c*) two sporogenous branches from which all the spores have fallen except the youngest and uppermost ; (*d*) young sporiferous hypha (× 700).

after one moult, a larger and larger number are found dead after each succeeding moult. In other words, if a few worms die after the first moult of this disease, a great many will be found dead after the second moult, and more still after the third moult, and they will all die after the fourth moult. There are not so many dead worms seen between two moulting periods. The reason for this is that in the hot weather it takes only three or four days for the disease to run through its full course, and in the cold weather eight to ten days, *i.e.*, the same period of time which intervenes between two moultings in the hot and the cold weather, respectively, so that the disease being contracted at one moulting period becomes manifest at the next. It is not meant that it is not possible for the disease to be contracted in the intervening periods. Worms with pebrine occurring in them in a latent form may contract the disease even when they are not moulting. Worms showing a good deal of muscardine at all times should be assumed to be full of pebrine also, and consequently sickly from the very first. Muscardine is much more contagious than other silkworm diseases. It sometimes happens that a man visiting a nursery free from muscardine after having visited one in which worms had been dying of muscardine starts muscardine in the other house also. Fortunately, however, the means of arresting this disease is simple and effective. The silk-rearers of Bengal throw away a lot of silkworms which show a few dead with muscardine after the first moult, knowing from their experience that the whole lot is destined to die before spinning. If no preventive measures are taken, the whole lot is bound to die off; but if such measures are adopted without delay, the further progress of destruction from this disease is at once arrested. The preventive measures will be described later on.

87. *External Symptoms.*—A microscope is not required for identifying muscardine. Pebrine and flacherie cannot be always made out from external symptoms, but muscardine can never escape detection. Soon after death, or immediately before death, worms affected with muscardine become pale and limp. A few hours after death they become rigid and pink or

red. If the fungus causing muscardine be *Botrytis Bassiana,* they become pink; if it be *Botrytis Tenella,* they become red, After remaining in this rigid state for about 12 hours, they appear like sticks of lime or chalk. By these external symptoms muscardine can be certainly identified without the help of a microscope. In Chapter III it has been said that worms from seed badly pebrinised are liable to be affected by other diseases also. If a worm which has died of muscardine be subjected to microscopic examination, corpuscles of pebrine may be noticed in abundance. Pebrine corpuscles should not be mistaken for spores of muscardine. There is some resemblance between them, but the latter are larger, more spherical, and less bright.

88. *Infection and the checking of its spread.*—If spores of muscardine are dusted over healthy silkworms after they have gone through the fourth moult, they do not as a rule take muscardine. They are subject to infection chiefly at moulting times. Darkness, quiescence, dirt, warmth, and moisture are the five conditions helpful to the growth of moulds. Muscardine being caused by a mould, is also encouraged by these five conditions. In the dark silk-rearing houses of Bengal all these conditions prevail at all seasons of the year. The chief reason for this is, Bengal silk-rearers neglect cleaning of the *dálás*. Most of them clean a *dálá* once in five or six days. Moulting silkworms lying buried in a heap of litter accumulating for five or six days are necessarily surrounded by all the five conditions spoken of, and they become liable to muscardine. Even in the cold weather the heat and moisture required for the development of muscardine are obtained inside a heap of litter. In some villages in Bengal a filthy practice prevails of heaping up litter in a corner of the rearing-room in the cold weather, with the object of generating heat at no expense, and thus getting worms to make cocoons within a short time. Muscardine easily breaks out in a rearing-room kept dirty in this manner. If silkworm-rearing is done in the January *bund,* the room should be kept warm by fire, and not by causing a heap of litter to ferment. This filthy practice not only helps the spread of muscardine, but of flacherie also. Where this practice prevails, muscardine does a greater havoc to the cold-weather crops than even to

the rainy-weather crops. Generally muscardine prevails more in the rainy season. In Chapter III it has been said the corpuscles of pebrine remain alive for seven months. The spores of muscardine, it should be remembered, retain their vitality for three years, unless excessive heat or fermentation destroys them. A rearing-room where infection of muscardine takes place once is liable to show it again if the next rearing is done within a period of three years, unless the old *dálás*, &c., are well rubbed with cowdung paste before the second rearing. If this rubbing (*leping*) is properly done, the spores of muscardine get agglutinated with the paste, and being unable to get about cannot do any harm to silkworms. Some silk-rearers are very negligent in this matter of *leping* their rooms and *dálás*. They begin rearing by *leping* one or two *dálás* only for the newly-hatched worms; and as the worms require more space, they get more *dálás leped* gradually. It is such idle men who sometimes give up cocoon-rearing on account of repeated ravages caused by muscardine, imagining that it is their ill-luck, as they call it, which brings muscardine every time into their houses. Sometimes they postpone rearing of worms for one or two years, and then recommence it to try their "luck" once more. But doing the *leping* of *dálás* in the same easy-going manner they lose their crop again from muscardine, and then give up the industry for good, taking refuge in the superstitious belief that the blind goddess* is unpropitiable. Silkworms dying of muscardine, the spores of this disease accumulate so abundantly inside and outside the rearing-house, that there is always a tendency for the disease reappearing in the same locality in future rearings. By special carefulness the spores can be destroyed. The harm from muscardine is a good deal avoided by the ordinary practice of rubbing the rearing-rooms, the surrounding walls, the yard in front and the *dálás* with cowdung, and of having *chandrakies* in a shed somewhat removed from the rearing-house. The disposal of the litter is also to be taken into consideration. If it is allowed to get dry and the spores to be carried about with wind, they may find easy access into rearing-houses. Litter should never be allowed to get dry, but stored in a pit or thrown in the dung-heap, a good way aloof from the rearing-house. Many rearers keep the litter scattered about in their yards in order to dry it and use it as fuel. This practice helps the spread of infection of muscardine and other silkworm diseases. Stored in a pit, or given to cattle, and the dung of the cattle being rotted, the litter cannot get dry and germs of diseases cannot move about in the form of dust in the silk-rearing village, spreading infection. The refuse stalks of mulberry may also be rotted in water, and a useful fibre, finer than jute, can be extracted out of them. Another precaution is useful in avoiding germs of muscardine and other diseases. The doors and windows facing the direction of the wind should be kept shut up, *i.e.*, when the wind is easterly, the east doors and windows should be kept closed, and so on. With the wind there always come into the room particles of dust, and with these germs of diseases may enter the rearing-room, whether perceived or not. Allowing free access of wind into the rearing-room in the dry season, *i.e.*, from November to May, leaves also get dried up too quick, which acts as an obstacle to silkworms making use of them. For ordinary silk-rearers rubbing the rearing-rooms and appliances with cowdung is a good enough protection. But one wishing to kill the germs effectively should use sulphate of copper and sulphur fumes every *bund* in disinfecting appliances. Both sides of *dálás* should be disinfected with the copper solution, which can be conveniently done by mixing up with the cowdung and mud paste, ordinarily used for *leping* one side of the *dálás* only, powdered sulphate of copper (1 part to 200 parts in weight of the paste), and rubbing both sides of the *dálás* with this mixture. The washing of the sheets of eggs first, then the nets, then the earthen cups for covering moths, then the *dálás*, the *chandrakies*, the bamboos for *máchâns*, the canvas and cloth used for covering mulberry leaf, should all take place in freshly-made solution of sulphate of copper (1 or ½ per cent. solution). They should be then taken into the rearing-room—all except the eggs and nets. The floor and walls of the rearing-room should be *leped,* and the posts of the *máchâns* washed with the remains of the solution on the same day. If any of the solution remains over after these operations, it should be sprinkled in the yard and all round the rearing-room. Old sulphate of copper water, unless it is kept stoppered up in bottles, is of no use. If an Eclair Vaporiser (Fig. 8) is used, the disinfection of rooms and their surroundings and rearing appliances can be done without much trouble, as the copper solution coming out of this machine as vapour, and spreading over a large area of space, the disinfection can be finished within half an hour. The sheet of eggs and the nets should be spread outside the rearing-room to get dry, as sulphur fumes do them harm. The other appliances being put in the rearing-room, and when they are still wet, half a seer of sulphur is to be burnt in the room, the room being kept shut up for 24 hours. Then the eggs and nets already washed in sulphate of copper may be taken into the rearing-room also, and the room thrown open. If the sulphate of copper solution is stronger than 1 : 100, a proportion of eggs dies off, and it is safer to use for washing eggs a solution 1 : 200 in strength. Nets must be washed in plain water after the sulphate of copper wash. Eggs hatching after disinfection, the crop cannot fail from *muscardine.* But the infectious nature of this malady is so great that muscardine may appear even among worms reared after such thorough

---

* The Goddess of Silkworms is called *Káni* (the blind woman).

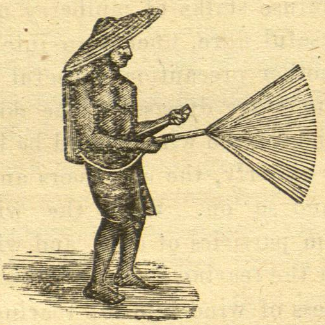


FIG. 8.—The Eclair Vaporiser.

disinfection, should the malady break out virulently in the locality in other silk-rearing houses. Whenever a worm is found in the litter dead with muscardine, the following plan should be at once adopted to stop an outbreak. All the *dálás* are to be so cleaned that no dead worms may remain on them. The floor of the room is then to be *leped* with sulphate of copper water, half a seer of sulphur burnt in the room immediately afterwards, leaving the room shut up for 6 hours. Feeding should not be done after the cleaning just referred to, but the worms fumigated in a hungry condition. Sulphur fumes do more good in a damp room and to worms kept fasting.

89. *Right Method of Fumigation.*—Some rearers complain:—"We have burnt sulphur, but we have not been able to check muscardine." This is simply due to their not doing the burning of sulphur in the right way. Rightly done sulphur fumigation never fails to check muscardine. (1) Some burn sulphur without cleaning the trays. This does very little good. It is only loose spores of muscardine that are killed by sulphur fumes, but the thousands upon thousands of spores that lie layer after layer in the body of a worm dead with muscardine cannot all be killed by the fumes. It is the rule, therefore, to fumigate after divesting the trays of all dead worms. (2) Some look upon the act of sulphur fumigation with superstitious horror, or assume that it is hurtful to silkworms; but when half their crop is lost through muscardine they burn a quantity of sulphur, thinking their worms are destined to die any way. Then they fail to see any benefit from the fumigation they do in this reluctant way. When half the worms have died of muscardine, the other half must have contracted the disease, and the spores having struck root the fumigation cannot do any good. It is the rule, therefore, to do the fumigation on the very first day one or two worms are seen in the litter dead from muscardine. (3) Some rearers do the fumigation without *leping* the floor of the rearing-room, and thus making the atmosphere of the room damp. This also does not prove quite effective. If by rain the atmosphere becomes moist of itself, sulphur fumigation does good even without the previous

leping of the floor. (4) The *leping* of the floor with sulphate of copper is a precaution that is seldom adopted. Fumes naturally rise upwards, and it is possible the spores of muscardine in the dust of the floor may escape the action of sulphur fumes. (5) Some rearers bring a pan of fire into the rearing-room, and sprinkle a quantity of sulphur over it. This extinguishes the fire, and very little of the sulphur becomes converted into fumes. The bulk of it is found settled down at the bottom of the pan in a thick crust. This way of fumigating also does little good. The proper method of burning sulphur is this: the sulphur is to be powdered and placed on an earthen or metallic pan, the pan being placed on a slow fire. The sulphur will gradually melt and catch fire of itself. In this state the pan is to be taken into the rearing-room and left there with the doors and windows completely shut. (6) Some rearers procrastinate about fumigation simply on the ground of economy. When they see a few worms dead from muscardine after a moulting period they hope they are only stray cases and the disease may not spread. They think they find their hope realized during the next three or four days, when few or none of the worms die from muscardine. After the next moult, however, they find out their mistake, and know they ought to have done the fumigation when they first saw the dead worms. Sulphur fumigation does not prove quite so effective when time is allowed to elapse. (7) One day's fumigation may not be sufficient to root out muscardine from a rearing-house. It has been said that a spore of muscardine if it once takes root inside the body of a silkworm is sure to kill the worm in spite of sulphur fumigation. It is therefore necessary to do the cleaning again the day after fumigation is done, and if any muscardine worms are found in the litter, that day also leaf is to be given to the worms after the cleaning; but an ounce of sulphur should be burnt in the room immediately afterwards and the room left shut up again for six hours. In this way daily, after the midday cleaning and feeding, an ounce of sulphur is to be burnt in the room so long as there is any muscardine worm seen in the litter. This treatment is sure to stop the progress of the disease.

90. *The use of Nets.*—In the last paragraph daily cleaning of *dálás* is recommended at least for a number of days. The way in which the cleaning is done in this country, *viz.*, by removing the worms with the hands from one *dálá* to another, makes it a very big business if 50 or 100 *dálás* have to be cleaned daily. In Europe perforated sheets of paper are used for this purpose. Fresh leaves are spread over them, the worms from underneath crawling up through the perforations on to the fresh leaf. Before the next feeding the litter from underneath the paper is taken out. For worms at different stages perforations of different sizes are employed; and after each rearing the sheets of paper are thrown away. As silk-rearing is done only once a year in Europe, it is not inconvenient using these papers. For this country, however, the use of such papers is not adapted. The use of thread nets used for catching small fish is best suited in this country for cleaning the trays of silkworms. The same nets do for worms of all sizes. Old but blackened nets can be bought very cheap from fishers, and if they are well selected, they last four or five years. The same nets can be used *bund* after *bund* without causing infection, if every time they are washed with sulphate of copper solution before washing them in plain water. If the worms are lifted up with the net after three or four feeds, they do not go through the meshes even when they are very young, as they lie on the matted remains of the mulberry leaves which are taken up clean on the net. If one or two small-sized sickly-looking worms are found under the net on the older litter, they should not be picked up, but thrown away with the litter. The *dálá* with the litter should be taken out of the room, and the litter thrown into the reservoir already alluded to. The net underneath the litter is also to be shaken clean, and the *dálá* and the net are then to be taken inside the rearing-room, and used again. When shaking the net clean, if a dead worm happens to be seen entangled in it, this is to be thrown into the litter, and a little powdered sulphate of copper or lime should be touched at that particular spot of the net. In the verandah or in a room adjoining the room where the cleaning is done,

a pot containing powdered sulphate of copper or lime should always remain suspended for this purpose. The litter should be collected and bundled up afterwards and carried away to a pit. The object of cleaning the *dálás* and nets outside the rearing-house is to avoid dust and the litter getting trodden down under the feet of the persons working inside. To use nets in the manner described above one requires 2 pieces for each *dálá*, or about 32 pieces for producing 1 maund of cocoons. Thirty-two pieces of old nets can be bought from fishers for Rs. 8. To many silk-rearers Rs. 8 is a great deal of money; but if they use them for one or two *bunds*, they will find the benefit far outbalancing the outlay. The use of nets is helpful not only in keeping the worms clean, but also in thinning them out. When they lie too thick on a *dálá* a net may be spread over the worms and leaf sprinkled over the net. When half the worms will appear to have crawled up to the fresh leaf, they should be taken up on the net and removed to another *dálá*. This is a very easy way of thinning out the worms. Another benefit that is derivable from the use of nets is the ease with which worms can be equalized when they happen to get disuniform, by separating out worms that have not gone to moult from those that have, by spreading a net over them and sprinkling leaf over the net, and removing the late worms along with the net. The use of nets also makes it very easy to manage the worms at moulting times. The worms that are seen lying motionless under a net when it is taken up are moulting worms. These should not be given any leaf, and the worms taken up on the net and removed to another *dálá* may require only one feed more before they also go to moult.

91. *Remarks about Copper Solution and Sulphur Fumes.*—With regard to the use of sulphate of copper, it should be repeated here that the solution should be used the same day that it is made. The solution kept in an open vessel becomes weaker and weaker in strength with the lapse of time. It should be also remembered that thread nets should be washed with plain water after they have been washed with sulphate of copper to save them from rotting. With regard to sulphur fumigation

also, one fact should be always kept in mind: the quantity of sulphur fumes that may kill rats, bats, lizards, and even men, does not do any harm to silkworms. No hesitation, therefore, should be felt in fumigating rearing-houses with sulphur when worms are being reared. Eggs and thread nets should not, if possible, be subjected to fumigation.

92. *Muscardine not hereditary.*—With regard to muscardine one more fact should be mentioned. Moths never transmit the spores of this disease to eggs; in other words, the disease can never be directly due to bad seed. The caterpillar affected with this disease never gets the time to change into a moth. It is, therefore, impossible for the disease to be transmitted from generation to generation, like pebrine is transmitted. But seed-cocoons containing chrysalides affected with muscardine may act as the exciting cause of the malady by loose spores from the cocoons dropping into the *dálá* on which they are kept or on sheets of eggs, and remaining inside the rearing-house. If, however, after taking away the seed-cocoons when they are used up, the *dálás* and sheets of eggs are washed with sulphate of copper, these loose spores also get killed. Muscardine is not to be thought of when moths are examined with the microscope in selecting seed, as moths are never affected with this disease.

93. *Native Methods for checking Muscardine.*—In some villages a belief prevails among cocoon-rearers that *dálás* being *leped* with country liquor, the recurrence of muscardine in a rearing-house is checked. This belief is not a mere superstition. But the germ-destroying power of spirits is not so strong as that of sulphate of copper, sulphate of iron, fumes of sulphur, borax, or alum. Of the substances just mentioned, sulphate of copper is the most powerful germicide, and its use is, therefore, urged so often, not only for arresting muscardine, but also flacherie and pebrine. Another belief prevails among cocoon-rearers that buffalo's dung, *bhela* leaf, onion, and garlic mixed up with water and fermented and then used for *leping dálás*, arrest the recurrence of muscardine. That some of these substances have germicidal properties is most probable;

but it is much easier to use sulphate of copper water than to procure these ingredients for a veritable witch's caldron. Indeed, if country liquor, buffalo's dung, and other substances had really given satisfactory results, they would have been in general use in villages, and rearers who once experienced their benefit would have continued using them. But the current belief among rearers is, there is no remedy against muscardine. Quite recently rearers trained in more rational methods of sericulture are getting such striking results from the use of sulphate of copper and of sulphur, that the use of them is spreading very fast. This fact also shows that no striking results have ever been obtained from the use of country liquor and other substances.

SUMMARY OF CHAPTER IV.

1. In Bengal muscardine does the greatest amount of damage, next to pebrine. It is the most highly contagious of all the silkworm diseases. A microscope is not required in diagnosing this disease.

2. It is in the moulting state, as a rule, that spores of muscardine take root in the bodies of silkworms. Pebrinised worms, however, offer a fit soil for the spores at all times.

3. It is after the last moult that pebrine makes its appearance in an outward form, but muscardine never as a rule begins its appearance after the fourth moult.

4. When only one or two worms dead with muscardine are noticed for the first time in the litter, all the *dálás* should be at once cleaned and divested of all dead worms. After the cleaning, the worms should not be fed; but the floor being *leped* with sulphate of copper water, half a seer of sulphur is to be burnt in the room, the room being left shut up

for 5 or 6 hours, and the feeding done afterwards. This arrests the further spread of the disease. If any worms dead with muscardine are noticed the next day also, cleaning should be done again and an ounce of sulphur burnt. This should be repeated daily until the disease disappears altogether.

5. The chief cause of this disease is neglect of delitage and storing litter in or about the rearing-room. Cleaning should be done daily with nets, and the litter rotted as manure in a pit.

6. Muscardine is never due to bad seed, as moths are never affected with it.

7. Muscardine is not to be looked for while examining moths under a microscope with a view to getting untainted seed.

CHAPTER V.

RASÁ OR GRASSERIE.

94. *Chief Cause and Remedy.*—Next to pebrine and muscardine grasserie does the greatest amount of damage in Bengal. In Europe no loss worth speaking of takes place through this malady. In fact there is a French proverb which says: "Unless one gets grasserie among his worms, one is not sure of his crop" ("*Pas de gras, pas de cocoons*"). Grasserie is neither contagious nor hereditary, nor is it caused by any living organism, like pebrine or muscardine is caused by. Pebrine, muscardine and flacherie being associated with living organisms, capable of reproducing their kind, they soon spread in the form of plagues. If a caterpillar affected with grasserie be pounded up with water, and if mulberry leaf dipped in this water and afterwards dried be given to other silkworms, they do not necessarily get grasserie. Grasserie does not affect the cocoons for seed. This disease never appears in moths, and it need not, therefore, be looked for when selecting seed with

the microscope. No systematic researches have been made in Europe in connection with this disease, as it is considered of so little consequence there. The cause of grasserie is not known in Europe. In Bengal, this disease sometimes assuming an epidemic form, the cause of it is not so difficult to ascertain. From November till May very little rain falling in Bengal, the air becomes excessively dry. If after two or three months of drought there happens to be a very heavy downpour of rain, and if there are silkworms at the last stage of their growth at that time, these are bound to perish through grasserie. In November 1892, for instance, there was heavy rainfall on Gouripur side in the district of Murshidabad, and worms in the villages in this locality being at the last stage at this time, they all perished through *rasá*. Silk-rearers can all cite examples of this nature. It is not to be inferred that it is only worms at the last stage of their existence that are liable to this disease. It is in the last stage of their life as caterpillars that silkworms are more liable to all forms of disease. That is why worms at the last stage suffer more from grasserie also if they suffer at all. If a lot of silkworms seems quite faultless, *i.e.*, even if a single dead worm is not noticed after the four moulting periods, a few grasserie worms at least will make their appearance at the very last day when they are making cocoons, as they do in Europe. If the worms are given leaf gathered from large trees, after an unexpected shower of rain following a protracted period of drought, they do not get grasserie in the epidemic form. Even the casual appearance of grasserie worms at the time of ripening can be avoided by divesting the branches, given to the worms at the last stage, of their tender tips. It is not, of course, advisable to take the trouble of divesting each branch of its tenderest leaves before giving it to worms to avoid one or two worms getting this disease. From the facts mentioned one should be able to infer that the cause of grasserie is worms accustomed to getting mature leaf suddenly getting to eat nothing but leaf containing an excess of moisture. The mulberry cultivation in Bengal is carried on in an unnatural manner—that is, the plants are not allowed to grow more than a few feet high each time they are cut. This results in the plants sucking up moisture by simple capillary action when there is a sudden downpour of rain after protracted drought, the moisture thus sucked up being mainly stored in the leaves. Large mulberry trees do not behave in this way. Their roots are buried deep in the soil, and a sudden shower of rain affects but the superficial layer of the soil, the depths of the subsoil remaining unaffected. The leaves of large trees being high up, mere capillary action cannot affect their consistency after a casual shower of rain. The vehicles for moisture in leaves are the roots and stems; so when the rain is over and the superficial moisture of the leaves is dried up, their consistency remains as before. Leaves of large trees not altering in consistency after a casual shower of rain, they do not produce grasserie when eaten by silkworms. It is most important that every cocoon-rearer should have a few mulberry trees for emergencies, as with their help they can avoid grasserie in the epidemic form. In the rainy season the consistency of leaf is not suddenly altered, on account of the rainfall being continuous; so that at this season worms get leaf containing an excess of moisture from the first to the last. Excessive moisture may produce flacherie, but unless there is any sudden change in the character of the food, grasserie does not break out. It is thus that grasserie never occurs in the epidemic form from June to October.

95. *Advantage of propagating Large Mulberry Trees.*—In Bengal large mulberry trees not being used for rearing silkworms, very little silk-rearing is done when the weather is most suitable for silk-rearing. Better cocoons are obtained in February by rearing silkworms in Lower Bengal with leaf gathered from trees than even November or March *bund* cocoons. In February large mulberry trees bear a luxuriant foliage of fresh and tender leaves, and the time being neither too hot, nor too cold, nor wet, is most suitable for healthy growth of silkworms. But Bengal mulberry bushes are most backward in February, three or four months of drought preceding this month. In February there is the further risk of

failure from grasserie, if Bengal mulberry is depended upon, and if there is a casual shower of rain at the last stage of the worms. This is why the spring *bund* is considered the poorest *bund* in Bengal, when it deserves to be reckoned as the richest. With leaf gathered from large mulberry trees, even the *Deshi* and *Nistári* worms can be satisfactorily reared in spring, as leaves at this season are very tender. The *Barapalu* and the European silkworms always do better on the tree mulberry than on the Bengal shrub mulberry. Beautiful cocoons of the *Barapalu* and the *Bombyx mori* can be reared in the plains of Bengal in February if leaves of large trees are used. The February *bund* might come to be recognized as a more important one than even the November *bund* if large trees were propagated in Bengal. Another advantage of using leaves from large mulberry trees will be described in Chapter IX.

96. *Various Minor Causes of Grasserie.*—Although grasserie in its epidemic form does not occur very often, a few cases of grasserie may be noticed every time silkworms are reared. The causes of such sporadic attacks are various—

(*a*) Worms getting mature leaf from the first, fed on a little more tender leaf when they arrive at the last stage, a sprinkling of grasserie will be noticed among them:—(1) Worms fed on leaf gathered from clay soil, given leaf from sandy soil during the last few days, get less nutritive leaf at the last stage, that is leaf containing an excess of moisture. (2) If they are fed on leaf gathered from an old mulberry plantation, and during the last few days only on leaf gathered from a new plantation, they also get more tender leaf at the last stage. (3) If they are fed on leaf from tall plants first and on leaf from very short plants only on the last few days, then also they get more tender leaf at the last stage. The best plan is to feed silkworms from the first to the last on leaf from the same plot of land, as in that case the leaf gets more and more mature by slow degrees with the growth of the worms.

(*b*) Worms at the last stage avoid eating tender tips of branches; but some worms happening to get nothing else to their individual lot for two or three feeds successively, fall to eating these tender leaves instead of moving about in the *dálá* in quest of mature leaf, and they get grasserie. In March 1890 an experiment on a large scale (*i.e.*, with worms that made about 16 maunds of cocoons) was undertaken at Lister's Grant (Majri) between Hurdwar and Dehra Dun, to prove this point. The worms in question were given leaf at their last stage after divesting it carefully of tender tips. Not a single worm of this lot took grasserie. In other lots of worms in the same silk farm, grasserie appeared in a sporadic form at the time of ripening, as it had done in former years.

(*c*) Worms at the last stage fed with leaf gathered from a shady place get grasserie, court and flacherie—all three in a sporadic form.

(*d*) In the rainy season worms kept in a draught of air take grasserie. This is also probably due to leaves imbibing more moisture or to interference with natural transpiration.

(*e*) If there is no ventilator at the top part of the rearing-room, and if there is considerable difference between day and night temperatures, some worms reared in this room die of grasserie. This is also probably due to the vapoury exhalation of the rearing-room not being able to get out but being deposited in the form of dew on the leaf, as it is seen that a bundle of leaf stored overnight in an ill-ventilated room is in a " sweating " condition in the morning.

(*f*) Mismanagement of worms at the moulting periods also results in a sporadic appearance of grasserie at every stage. It probably happens in this way. Before all the worms have gone to " sleep," the feeding is sometimes stopped by mistake. The worms that have not gone to sleep require to eat more leaf before they can go to sleep. Under the circumstances they are obliged to eat the dry and decayed leaf of the litter and then go to sleep. When they get over the stage they find the early worms already eating fresh leaf, and they fall to eating it also before their time, and it is these worms that take grasserie. By the use of nets even unprofessional men can distinguish which worms have gone to moult and which have not in a mechanical way, and they can feed the latter until they have gone to moult, and not resume feeding until they are all *well out* of the moult.

(*g*) Mulberry leaf affected with *tukrá* and eaten by silkworms gives them both flacherie and grasserie.

97. *Distinction between Grasserie and Flacherie.*—All these minor causes assigned for grasserie have at their bottom

the sudden use of leaf containing an excess of moisture. Most of the causes assigned for grasserie are the causes of flacherie also. Some sericulturists in Europe have opined that the two diseases are identical. In Europe flacherie is very much prevalent among silkworms. As grasserie appears also when flacherie breaks out, the former has been looked upon by some as a different form of flacherie. This opinion, however, is erroneous. A chill may give rise to cold in the head, fever, or dysentery in the human subject. That these three diseases have certain common causes does not make the diseases identical. This subject will be further discussed in Chapter VI.

98. *Relation between Pebrine and Grasserie.*—As worms reared from seed free from pebrine suffer less from muscardine, court and flacherie, they suffer less from grasserie also, even when one of the causes of grasserie is present. It has been repeatedly said that pebrine acts as the latent cause of all the other diseases. Grasserie is akin to cold in the human subject. As weak persons are more subject to cold, so silkworms with the inherent weakness caused by pebrine are more subject to grasserie.

99. *External and Microscopic Appearances.*—Every silkworm-rearer is familiar with the external appearance of grasserie. The caterpillars affected with this disease become restless, and bloated and yellow in appearance. A purulent matter exudes from the body if it is punctured with a pin. The silk-glands of these worms and other tissues are converted into this purulent substance. It is not exactly fatty degeneration of tissues, but it is akin to it. Observed with a microscope this matter appears in the shape of numerous spherical crystals. Looked at more attentively, these will be seen not to be quite spherical, but polyhedral. Looked at more attentively still, faint lines will be noticed, and a concentric circle or polyhedral body in the middle of each. Fig. 9 is a diagramatic representation of grasserie crystals. These crystals are

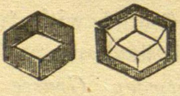


FIG. 9.—Grasserie Crystals, represented diagramatically.

larger than the urine crystals that are noticed when moths are examined with a microscope, but they are not all of the same size. The grasserie crystals have no resemblance to fat globules. The difference in appearance between liquid taken from a healthy moth and that from a caterpillar affected with grasserie is represented in Figs. 10 and 11.

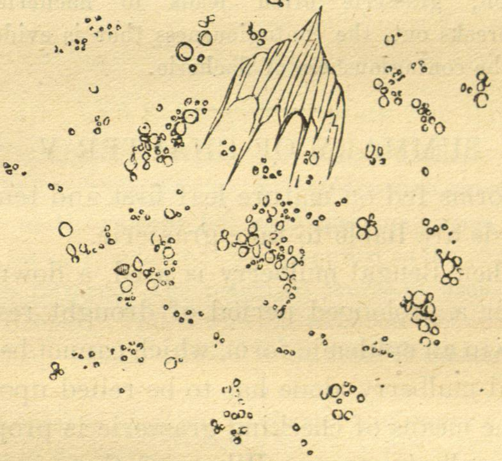


FIG. 10.—Microscopic appearance of liquid from healthy Moth (× 600).

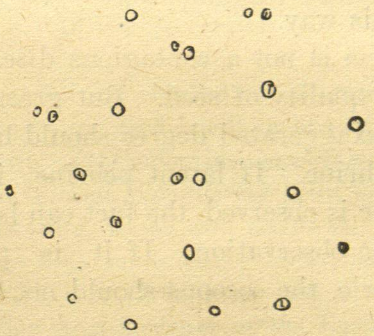


FIG 11.—Microscopic appearance of liquid from a Caterpillar affected with Grasserie (× 600).

100. *Contagiousness.*—As the disease occurs at times in an epidemic form, it may be mistaken for a contagious disease. But grasserie is not a contagious disease. A common cause subsisting at one and the same time, in other words, worms being all suddenly given leaf containing an excess of moisture, they may all take grasserie. But as worms dying from any cause, ferments of flacherie are generated simply by natural putrefaction, grasserie often leads to flacherie. When flacherie breaks out, the contagiousness that is evident afterwards is the contagiousness of flacherie.

SUMMARY OF CHAPTER V.

1. Worms fed on mature leaf first and tender leaf afterwards are liable to take grasserie.

2. When Bengal mulberry is used, a downpour of rain after a prolonged period of drought results in grasserie in an epidemic form, which cannot be checked if Bengal mulberry alone has to be relied upon.

3. The means of checking grasserie is propagation of large mulberry trees. Whenever there is a sudden shower of rain after drought, leaves from trees should be used for a few days afterwards. Grasserie is avoided in this way.

4. Grasserie is not a contagious disease. It does not affect the quality of seed. But grasserie when it occurs in an exaggerated degree should be taken as indicating pebrine. If latent pebrine is suspected when grasserie is observed, the fact can be ascertained by microscopic observation. If it is pebrine that caused grasserie, the cocoons should not be used for seed.

5. The chief cause of the sporadic appearance of grasserie is the mismanagement of worms at moulting

periods. Feeding should not be stopped until all the worms on a *dálá* have gone to moult, and feeding should not be recommenced until all the worms on a *dálá* are *well out* of the moult. Worms that are not well out of moult are likely to take grasserie if they are allowed to eat leaf when they are still in a half sleepy condition.

CHAPTER VI.

KÁLSHIRÁ AND SHALFÁ (FLACHERIE AND GATINE).

101. *Extent of the Disease.*—In Bengal flacherie is regarded as less injurious than pebrine, muscardine and grasserie. The discovery of M. Pasteur has made pebrine almost a thing of the past, though flacherie is still regarded as the most dreadful disease in Europe. The principal causes of flacherie do not occur in Bengal. This is why flacherie does not cause so much havoc among Bengal silkworms as it does among European silkworms.

102. *Causes of Flacherie.*—We will now describe the principal causes of flacherie—

(*a*) *Seed getting spoilt.*—In Bengal silkworm eggs hatch, as a rule, within 8 to 15 days. There is thus little chance of Bengal eggs (except *Barapalu* eggs) getting heated or fermented before hatching. In Europe careless conservation of seed for a period of 10 months may result—(1) in its getting heated; or (2) dried up with sun or wind; or (3) mouldy with damp. Worms hatching from seed spoilt in any of these ways are liable to flacherie. (4) Conserving eggs for such a long period may also result in their experiencing great and sudden differences of temperature, which also makes the worms hatching out of the eggs thus subjected to variations of temperature liable to flacherie. In 1891 there was a wholesale failure of the silkworms from flacherie in the Kashmir State. The cause of this was not opening out the covers of the earthen pots in which eggs were conserved a month before hatching. That year these covers were taken out immediately before the hatching took place. On opening out the covers the space inside the earthen vessel felt quite hot, which was a clear indication of fermentation having set in among the eggs. The hatching took place within three or four days after the eggs were taken out and distributed. Later on nearly all the worms died of flacherie. On the 9th January 1893 some silkworm eggs were received in Kashmir from France. When these were despatched from France winter had already set in in that country. In coming through the Mediterranean Sea, the Red Sea, the Arabian Ocean, and in the railway journey across the western portion of India, the eggs experienced high temperature. On their arrival in Kashmir again they experienced a second period of cold. Ordinarily, eggs experiencing such diversities of temperature, the worms from them perished through flacherie. But most of these eggs were washed with sulphate of copper solution, while a small portion was left without this wash for trial. Every worm from the latter portion perished through flacherie, while the former portion, which was treated with the copper solution, produced the full quantity of cocoons. *Nistári* or *Chhotapalu* eggs sent by post from one place to another may get heated *en route*, and the worms from such eggs may take flacherie. It is therefore always important to dip any seed that is received by post in sulphate of copper solution.

103. (*b*) *Hereditary tendency.*—Cocoon-rearers both of Europe and of Bengal have a notion that cocoons spun by a lot of worms that show the least sign of flacherie should not be used for seed. Notwithstanding the existence of this notion, seed from worms affected with flacherie is often dishonestly sold in Europe as good seed. Whether 10 months ago, when a lot of worms were making cocoons (out of which the eggs sold were obtained), any flacherie was noticed or not can be ordinarily inquired only of the seller of the seed. In this country, however, deception cannot be practised in this matter, as it is the custom in Bengal for rearers to buy cocoons instead of eggs for seed, and to see the worms in the act of spinning before

they buy the cocoons. This is an excellent practice. It should, however, be mentioned here that the sulphate of copper dip does away with the hereditary tendency to flacherie. In October 1892, the Rev. A. Campbell of Pakhuria, in the district of Manbhum, undertook to supply *Chhotapalu* seed to a number of cocoon-rearers in Malda and Rajshahi. These men gave notice when the rearing was going on at Pakhuria that they wanted the seed to hatch on the 2nd or 3rd of November. If the worms at Pakhuria were allowed natural conditions, the eggs from them would have hatched on the 11th and 12th of November. The rearing-room was therefore kept unnaturally warm both day and night to hasten ripening, so that the hatching of the eggs might take place about the 2nd and 3rd of November. The temperature at this time was naturally about 75° Fahrenheit, which is the most suitable temperature for rearing silkworms. To get the seed at the proper time the temperature of the rearing-house was kept at 85° Fahrenheit. A fourth part of the worms died of flacherie before spinning under this unnatural treatment. The eggs from this crop were washed in sulphate of copper solution and sent to the rearers of Malda and Rajshahi. About 150 rearers had this seed, and they all got excellent result, no trace of flacherie being seen in their houses. That eggs derived from a lot of worms which show flacherie must necessarily fail on account of flacherie unless they are dipped in sulphate of copper solution is not asserted. Bengal silkworms from seed free from pebrine, but derived from a crop which showed flacherie, when reared with leaf of good quality and in mild temperature, do not, as a rule, show flacherie.

104. (*c*) *Overfeeding of Worms.*—The silk-rearers of Bengal cannot afford to feed their silkworms more than three or four times a day, and they are therefore unacquainted with the fact of silkworms getting flacherie when they are too handsomely treated. No harm takes place if young worms are fed four or five times a day. On the other hand, when the atmosphere is very dry, they are benefited by one or two extra feeds. But at the last stage of the worms they should be given only three

feeds a day. Four, five, or more feeds per day at the last and most voracious stage of the worms gives them flacherie to some extent. In Lister's Grant near Hurdwar, in 1890, a European assistant of the silk farm kept a few silkworms in his bedroom with the greatest care with the object of seeing how greatly the race of silkworms might be improved by perfect cleanliness, even temperature, and constant feeding with leaves freshly gathered from trees. To his surprise the worms so carefully reared nearly all died of flacherie. Twelve maunds of cocoons were spun without any signs of flacherie in a rearing-house in the neighbourhood where the same seed was used; only the worms which spun these were given three feeds a day. In Mysore silkworms suffer a great deal from flacherie. There the custom prevails of feeding them five or six times a day. In Malda four feeds a day are ordinarily given by cocoon-rearers to their worms. In the village of Kagacheria in that district, a rearer feeding his silkworms at their last stage three times a day, instead of four, is actually getting better cocoons than his fellow-villagers. In Chapter V it has been said that grasserie resembles cold in the human subject; flacherie, in the same way, may be compared to indigestion. As constant feeding may bring on indigestion to man, so it may do the same to silkworms. One should not pity a lot of silkworms because they are sitting on bare branches on *dálás* anxiously looking for food. It does them good when they have nothing to eat for an hour or two between the meals.

105. (*d*) *Wet, "Sweating," Dewy, and Fermented Leaf*.—Bengal silk-rearers are more careful about avoiding wet, "sweating," dewy, or fermented leaf than the silk-rearers of France and Italy. One can easily imagine how difficult it is to feed silkworms in the rainy season with leaf wiped of all superficial moisture. But Bengal silkworm-rearers have the notion that it is better to let silkworms starve than to give them wet or fermented leaf. One should stir the store of leaf as soon as one enters the rearing-room for feeding silkworms. The store of leaf should be again stirred before leaving the room after the silkworms have been fed. One or two small windows

or ventilators at the top part of the room prevent "sweating." If the exhalations from silkworms cannot escape from the rearing-room, they become deposited in the form of dew on the leaf at night, when cold converts vapour into water. The dew deposited on the leaf looks like perspiration.

106. (*e*) *Leaf submerged in Water or full of Mud.*—Excessive rainfall sometimes results in the mulberry field getting completely or partially submerged under water. When the water subsides the leaf may look fresh and clean, but such leaf gives flacherie to silkworms. In some villages in Bengal leaf of this kind is called "*bishal*" (poisonous) leaf. When mulberry leaf becomes submerged under water fermentation sets in, but water going down shortly afterwards the process of fermentation is arrested, and the leaves regain their look of vitality; but such leaf containing seeds of flacherie gives rise to this disease. If mulberry plants remain too long submerged under water, they rot away and perish. Bengal silk-rearers are well aware of the harm that comes from *bushal* leaf.

107. (*f*) *Leaf from a New Plantation and from a Shaded Plot of Land, and Coarse Leaf.*—In Chapter V it has been said that flacherie and grasserie have certain common causes. Silkworms may take either flacherie or grasserie fed on leaf containing an excess of moisture. But worms fed on leaf which is too coarse take only flacherie, never grasserie. Some of the causes of flacherie and grasserie are distinct. The two diseases are not identical. Their microscopic characters are quite distinct. Silkworms have to eat a larger quantity of leaf containing an excess of moisture, in order to get the requisite nutrition for their support. The accumulation of a large quantity of moist leaf in the stomach of the silkworm may result in its getting fermented, gases being generated, and flatulence of the stomach taking place. The droppings of silkworms so affected are not dry and detached, as in the natural state, but moist and in chains. The excessive moisture of the leaf sometimes comes out in the form of a liquid discharge from the mouth. The purging and vomiting both indicate an obstacle in the free transpiration of moisture from the skin of the

silkworms. Silkworms do not pass any liquid excrement, and the only means of outlet they have for the moisture ingested with the leaf is transpiration from the skin. There is a simple method of helping free transpiration from the skin of silkworms. This is having one or two ventilators at the top part of the rearing-room and keeping one or two maunds of quicklime in the room. Quicklime means newly-burnt shells or limestone nodules (*ghuting*) unslaked with water. Coarse, dry, or spotted leaf, leaf affected with *tukrá*, and leaf of *Morus Nigra* (that is the tree which bears luscious fruits and found in gardens attached to European houses), which is harsh and hairy, also gives indigestion (*i.e.*, flacherie) to silkworms. *Nistári* and *Barapalu* worms do not mind eating coarse leaf, as they digest their food more easily than the *Chhotapalu;* but the *Chhotapalu* silkworms are very particular in this respect, and they get flacherie more easily if they are given to eat leaf of any of these sorts.

108. (*g*) *Want of Ventilation.*—This cause of flacherie has been already treated of in speaking about the sweating of mulberry leaf. Cocoon-rearers of Bengal keep their rearing-rooms completely shut up for fear of the parasitic fly, and very little ventilation is therefore allowed. If windows fitted with wire-netting or with bamboo *chiks* are employed, ventilation can take place with impunity.

109. (*h*) *Excessive Heat.*—The temperature most agreeable to man is also the temperature best suited for rearing silkworms. If this is borne in mind, a cocoon-rearer can easily dispense with a thermometer. Silkworms are at the optimum temperature if they can be kept day and night at one of 75° F. But it is practically impossible to secure the temperature of 75° F. day and night. Generally speaking, the limit of 70° to 80° F. should not be exceeded. When silkworms are reared at a temperature above 85° F. they become liable to flacherie. Excessive heat causes want of appetite. This is a kind of indigestion. But when a silkworm gets this form of indigestion, its dorsal vessel (the heart) does not get black,* nor do the droppings become moist and connected in chains, nor does it vomit out any liquid matter. The indigestion caused by excessive heat is characterized by paleness of the worm, and it may be

---

* (*Kálshirá* = black vein).

then mistaken for a pebrinised worm. The worm looks pale and translucent owing to the absence of food in its stomach. When worms are ripening those affected with this disease at the time look like ripe worms. There is one external character by which it can be distinguished from pebrine. Pebrinised worms get shortened, but worms affected with this form of flacherie retain their natural length. Worms so affected, if they are brought out into the open air, sometimes feel recovered; being kept in fresh air, fall to eating leaf again, and lose their pale appearance. A lot of worms which show a few pale worms of this kind may be objected to for seed purpose on the suspicion of being pebrinised. When such suspicion arises a microscope should be employed to decide the matter. If the cocoons are used for seed, the eggs should be dipped in sulphate of copper solution before they hatch. Experienced rearers are aware of the distinction between pebrine and this form of flacherie. This form of flacherie is known among them by different names in different places. It is called "Tátke" (produced by heat), "Shalfá" (translucent), or "Hánsá" (white). In France this form of flacherie is called Gatine.

110. (*i*) *Dust.*—The rearing-room should be so carefully dusted and scrubbed that dust may not be raised. The *dálás* should be taken out of the rearing-room before throwing the litter out of them and shaking the nets clean. Rearing should be commenced after ascertaining the direction of the prevailing wind. Uninterrupted access of air into the rearing-room causes dust to enter into it also, and the room becomes hotter in summer and colder in winter, as another consequence of this.

111. (*j*) *Worms kept too thick on Trays.*—When worms are kept too thick on the rearing baskets, and leaf underneath them gets heated, the germs of flacherie accumulating in the fermenting leaf give rise to the disease.

112. (*k*) *Accidental Death of Worms from Injury.*—It is not to be expected that even under the best surroundings a single caterpillar out of hundreds of thousands that are reared

may not die of some accident or other. Some get punctured by some accident and die; some get into awkward positions under branches of mulberry and litter, and are unable to get on to fresh leaf; some are killed by spiders; and some are attacked by the parasitic fly. Worms thus dying accidentally should be put out of the rearing-room before they get time to putrefy. Worms putrefying, the germs of flacherie are generated inside them, whatever may be the cause of death. Other worms coming in contact with the putrefying worms are liable to get flacherie. Dead worms should not be thrown out carelessly from rearing-houses anywhere and everywhere. These should be first thrown in the litter and then removed with the litter to the pit, where it is left to rot. If litter is allowed to be devoured by cattle, dead worms also find their way into the stomach of the cattle. This does no harm. Cow-dung is a valuable substance, and it is never allowed to lie about. It is gathered and stored for manure or burnt as fuel. If litter and dead worms are left in the yard to be trodden upon by people, they get dry, and dead worms become converted into dust, and the dust may be carried with wind into rearing-houses, carrying infection. Put into the litter and afterwards removed to the pit or allowed to be eaten by cattle, there is no chance of their getting trodden down, drying up, and dust rising from them. When cleaning *dálás* and nets in the anteroom or the verandah of the rearing-house, dead worms may be sometimes noticed adhering to nets or leaving a wet mark on *dálás*. When this happens powdered sulphate of copper or lime kept in a pot in the verandah should be touched, and the particular spot of the *dálá* or net where the dead worm rested disinfected with a touch of the powder.

113. (*l*) *Debility.*—Debility of silkworms, however it may arise, gives rise to flacherie. Some races of silkworms are naturally weak. In Bengal the *Chhotapalu* variety is the weakest. All conditions being the same, *Nistári* and *Barapalu* worms may not show any specimen affected with this disease, but the *Chhotopalus* are likely to show some. Worms not getting two or three feeds successively, by some chance or other, get debilitated, and these afterwards show signs of flacherie. If worms are kept in very high temperature in day-time and in low temperature at night, *i.e.*, if worms instead

of being reared in properly closed rooms are reared in open sheds, they get debilitated, and flacherie breaks out among them. In very cold localities Bengal silkworm eggs sometimes take more than a month to hatch. Worms from eggs hatching in this way have a tendency to take flacherie. Worms kept in mud houses with straw thatching, close to a sheet of water and under the shade of trees, get the best condition regarding evenness of temperature both in summer and winter. Worms reared in such houses grow up more vigorously.

114. *Characters of the Germ associated with Flacherie.*—Looked at from a scientific point of view only, flacherie is a more complicated disease than either pebrine or muscardine. A live corpuscle of pebrine or a spore of muscardine inoculated into a silkworm is bound to produce pebrine or muscardine in that silkworm; but a germ of flacherie finding access into the body of a silkworm may or may not give rise to this disease. Worms from seed free from pebrine have been given in their young stage wet and fermented leaf and leaf steeped in fluid teeming with germs of flacherie, and yet they have not succumbed to the disease. The germs of flacherie multiply inside the stomach of silkworms under three conditions: (1) when the worms are naturally weak in digestion; (2) when there is an accumulation of moist or otherwise indigestible mulberry leaf in the stomach; and (3) when there is hindrance of free transpiration from the skin. The germs of flacherie are not generated inside the bodies of silkworms only. They grow in abundance in any vessel where mulberry leaf is left steeped in water. Whether a silkworm is affected with the disease flacherie or not can be made out certainly by examining it when it is still alive, a little fluid from its stomach being subjected to microscopic observation: (1) if there is no germ of flacherie discovered in the fluid, the disease is not flacherie; (2) if the germs of flacherie are seen, the disease is certainly flacherie; (3) when the germs are seen in the fluid taken out of a dead and putrefying silkworm, it cannot be determined with certainty whether the silkworm had the disease flacherie, or it got the germs by the natural process of putrefaction; (4) in examining moths for the selection of seed, the same principle should be borne in mind. If the germs are seen in the

fluid taken out of a live moth, it is certainly affected with the disease flacherie. If, however, the moth had died before the examination the occurrence of the germs proves nothing: they may have generated by the natural process of putrefaction. If the juice from the moth subjected to microscopic observation is found free from pebrine corpuscles, the eggs laid by that moth are not to be rejected. Whether the germs of flacherie have originated from the disease (flacherie) or from putrefaction after natural death, the harm is corrected by dipping the seed selected out as being free from pebrine in the sulphate of copper bath.

115. *The Development of the Germs.*—There are some differences of opinion among scientific men regarding the germ of flacherie. Some maintain that the different shaped germs seen under a microscope when a little fluid taken out of a caterpillar affected with flacherie is examined are various stages of the same organism. Others maintain that there are two distinct organisms concerned: one producing *gatine* and the other flacherie proper. Gatine is the "*hánsa*," "*tátke*" or "*shalfá*" of Bengal. The germs of gatine appear like minute points under the microscope. Those who regard flacherie as a distinct disease maintain that worms affected with flacherie show little rods or vibrions under the microscope. If the various stages for development of gatine and flacherie worms are observed, one will be inclined to regard the various germs connected with them as different forms of the same germ. Flacherie worms sometimes present the minute dots, and gatine worms present the vibrions and rods. Gatine worms after death become black like flacherie worms, and a nauseous smell comes out of both. Worms dead of flacherie or of gatine present exactly the same germs. Worms affected with flacherie when still alive sometimes show no vibrions, but the minute dots only. Both kinds of worms present the fast-moving vibrions immediately before or after death. A little while, *i.e.*, two or three hours, afterwards, the fluid from both kinds of worms presents two or three rods joined end to end, and moving about slowly and gracefully in the field of the microscope. The germs look wider at this stage. In the chrysalis and moth stage, germs in this condition are sometimes seen; but oftener the fluid of the insects in the

chrysalis or moth stage affected with flacherie presents only the appearance of little strings of pearls. When moths affected with flacherie are quite dry or very nearly so, and they are subjected to microscopic observation, they show little detached pearls only. These pearl-like spores are not unlike pebrine corpuscles—only they are very much smaller, being about $\frac{1}{5}$th the size of pebrine corpuscles (Fig. 12).

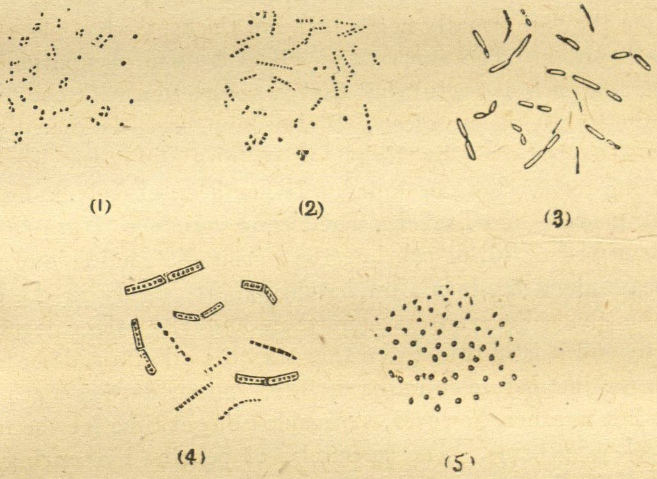


FIG. 12.—Development of the Germ of Flacherie × 600.

116. “*Upra-kháoá.*”—Flacherie and pebrine sometimes unite in destroying silkworms in such an extraordinary manner that the occurrence looks quite weird and supernatural. Sometimes the worms die off all at once on the day before ripening would have taken place. Sometimes the top *dálá* escapes destruction altogether, but the two or three *dálás* immediately underneath do not show a single live worm; below that again, sometimes, an odd *dálá* escapes the plague; the worms in three or four *dálás* below that are found dead and the two or three lowermost *dálás* also escape the plague. When this happens superstitious silk-rearers think a big kind of owl, which they call *Rát-chorá*, or night thief, has flown over the rearing-house

at night and cursed the worms. At the last stage of the worms many cocoon-rearers may be seen keeping watch outside the rearing-house at night to prevent the flight of the owl over their houses. There is also a belief that the curse of the owl takes effect only when the rearing-house is left without human occupation. Rearing-houses when occupied by men are naturally kept cleaner, and bad smell of close atmosphere is also naturally avoided. When they are not used for human habitation they are usually neglected, and the rooms feel close and smell strong. The superstition about human occupation of rearing-houses is useful, but that in connection with the flight of the owl is meaningless. Worms sometimes become *Uprá-kháoá* (=destroyed by flight), in spite of night watches and rearing-rooms being occupied. It has been already indicated that pebrine and flacherie combining produce *Uprá-kháoá*. When seed is full of pebrine, the worms die wholesale of this disease about 30 days after hatching. It is only in the cold season that silkworms are more than 30 days in the caterpillar state, and it is in this season that they die all of a sudden from pebrine just before spinning or three or four days earlier. In the hot weather, however, worms do not get time for the fatal attack of pebrine. The corpuscles of pebrine harbouring inside the silkworms enfeeble them, and if they are kept in an ill-ventilated room they become subject to flacherie. The air of the top part of the rearing-room is more impure than of the bottom part. So *Uprá-kháoá* chiefly happens to top *dálás*. But the topmost *dálá* usually escapes. The reason for this is, there being no *dálá* above it, the atmosphere above is not so confined. That some of the lower *dálás* escape destruction more or less is to be explained by the fact that 16 or 17 *dálás* being superposed one above another, some come into such close contact one with another that interchange of the atmosphere enclosed within them becomes difficult. Worms enfeebled with pebrine placed in such confined atmosphere necessarily get flacherie. *Uprá-kháoá* cannot happen (1) if cellular seed is used, or (2) if there are ventilators at the top part of the rearing room kept open day and night.

SUMMARY OF CHAPTER VI.

1. The day before the hatching of eggs takes place. *i.e.*, when they turn dark in colour, they should be washed in sulphate of copper solution, put out immediately afterwards to get dry, and then taken into the rearing-room already disinfected with sulphate of copper.

2. It should be always seen that no accumulation of decayed mulberry leaf takes place, nor any dust raised, in the rearing-room. If *dálás* are taken down from *máchāns* and replaced in them quietly, if sweeping of the room is done gently, if cleaning is done daily with nets, if young worms are fed not more than five times a day and those at the last stage not more than three times a day, and if *dálás* and nets are shaken or dusted clean outside the rearing-room, very little possibility remains for flacherie breaking out.

3. Leaf that has been submerged in water, leaf to which mud remains adhering, leaf from a new plantation or from a shady place, or rough and coarse leaf produce flacherie. Such leaf should never be given to worms. Mature leaf, such as is most suitable for the last stage of *Barapalu*, *Nistári* and European silkworms, gives flacherie when it is eaten by the *Chhotapalu* variety of silkworms.

4. Leaf wet with rain or dew, leaf that has got fermented being stored in a room and kept unstirred for a long time, and leaf affected with *tukrá* (=curl) produce flacherie.

5. There should be a number of ventilators fitted with wire-gauze or bamboo *chiks* in a rearing-room

These should be kept open day and night in the hot and rainy seasons. In the cold season also one of these should be left open day and night (Fig. 13).

6. Silkworms get gatine when hot wind is allowed to find free access into the rearing-house in summer. Worms affected with gatine may be mistaken for pebrinised worms, but microscopic observation of a little fluid enables one to decide that gatine is caused by the same germs as flacherie. Gatine is avoided by having the doors and windows through which hot wind might find direct access completely shut up, and also by having ventilators open.

7. Worms kept too thick on trays may take flacherie.

8. Worms getting accidentally hurt and dying, if allowed to putrefy in the feeding basket, germs of flacherie are generated. When cleaning *dálás* and nets, powdered sulphate of copper or lime should be touched wherever a dead worm is seen. To do this conveniently a pot containing either of these substances in a powdered condition, and another containing water should be kept always in readiness in the verandah where cleaning is done, so that whenever an occasion will arise, a finger can be put first in one pot and then in the other, and the portion of *dálá* or net where the dead worm is noticed touched with the finger.

9. Little calico bags containing lime should be used in dusting the trays each time cleaning is done. Fresh leaf should be given after the dusting.

10. Great differences of temperature between day and night should be avoided.

11. *Uprá-kháoá* is caused by flacherie and pebrine subsisting together in silkworms. If seed is free from

pebrine, and if there are ventilators in the rearing-room for the exit of impure air, this phenomenon can never happen.

CHAPTER VII.

Lali (Court) Gájlá-koá (Satiné Cocoon), and Génthé-koá (Double Cocoon).

117. The above three conditions are not diseases properly so called, but abnormalities only.

118. *Láli or Rangi.*—In some seasons, especially in February and March, *rangi* sometimes causes considerable loss. When any considerable loss takes place from this cause, it should be put down to latent pebrine. Worms reared from seed free from pebrine are seldom affected with *rangi*. When worms do not get sufficient supply of food, or get food of a character wanting in nutrition, all the organs of the silkworms sometimes develop, with the sole exception of the silk glands. When this happens the caterpillars change into chrysalides without spinning cocoons or spinning only very flimsy ones. Sometimes these chrysalides change into moths and even lay eggs. If these eggs are reared, the silkworms produced from them show an exaggerated extent of *rangi* at the time of ripening in spite of sufficient nutrition. In February and March the leaf of the Bengal mulberry is wanting in nutrient properties, and there is then some difficulty experienced by silkworms at this season in the proper formation of all their organs. A great deal of *rangi* is therefore seen at this season. The leaves of mulberry bushes growing in shade and those gathered from a new plantation are also thin and wanting in nourishment. Such leaf also produces a little sprinkling of *láli*. The abnormality having a hereditary tendency, cocoons spun by worms which show *láli* should not be used for seed. It should not, however, be inferred that worms which show this abnormality are derived from a weak stock. Seed free from pebrine produced from a crop which shows a sprinkling of *láli* at the

time of ripening may produce *láli* again in the next generation; but *láli* has no tendency to induce other diseases, like pebrine has. That worms showing *láli* are not naturally weak can be illustrated by the example of the Endi or Eri (*Attacus Ricini*) silkworms. Some races of Endi silkworms are almost wild, and they are very hardy. Every time they make cocoons, however, a few show this abnormality, *i.e.*, change into chrysalides without making cocoons. *Láli* is called *court* in the French language. *Court* means "short." In Bengali another synonym for *láli* is *kurkutté,* which also means "short." The caterpillars turning *short* and *red* in becoming chrysalides, this abnormality is called *láli* or *rangi* (red) and *kurkutté* (short).

Gájlá-koá.—This also is an abnormality,—not a disease. *Gájlá* cocoons do a great deal of damage to the silk industry. From such cocoons thread cannot be reeled out freely. The fibre coming out in lumps every now and again gives a great deal of trouble when *gájlá* cocoons are reeled. In the rainy season, or at other seasons when the atmosphere happens to be very moist, the fibres coming out of the silk glands instead of getting immediately dried up remain sticky for a short time, and get agglutinated with their neighbouring fibres when cocoons are formed. European factors often become considerable losers by buying *gájlá* cocoons, as these make coarse and knibby silk. They are often obliged to stop the purchase of cocoons in the rainy season. The coarse native reeled silk is largely made out of *gájlá* cocoons. The remedy against this abnormality is very simple. After putting the ripe worms on *chandrakies,* they are to be taken into a well shut-up room. In this shut-up room there should be about two maunds of freshly-burnt shells or limestone, *i.e.*, quicklime. This substance imbibes the moisture of the atmosphere inside the room, and the dry state of the atmosphere helps to dry up the silk fibres as soon as it is thrown out of the mouth of the silkworm. If there is heavy rainfall in winter at the time of the ripening of silkworms, the *chandrakies* are to be placed in a shut-up room, which is to be kept heated with fire. Even cold-weather cocoons may become *gájlá* unless this precaution is adopted. In Europe *gájlá* cocoons are called "satinés."

Génthé-koá.—These are called "double cocoons" in Europe. In Europe, and in China and Japan, two or three caterpillars sometimes combine to make one cocoon. In Bengal also sometimes two caterpillars combine to make one cocoon, but such cocoons are extremely rare among the *Barapalu*, *Nistári*, and the *Chhotapalu* races. In Europe, in China and in Japan the proportion of double cocoons sometimes exceeds 60 per cent. In Bengal one does not find even one double cocoon in a thousand. Where annual cocoons alone are reared, there is some reason for double cocoons occurring in such exaggerated proportions. Double cocoons cannot be reeled; so unscrupulous *graineurs*, instead of treating them as "waste," seed them, and sell the seed to other people, themselves, of course, avoiding to use the seed. Seed obtained from double cocoons produces a larger proportion of double cocoons at the next generation. Dishonest practice of this kind being more common in China and Japan than in Europe, the proportion of double cocoons is usually very great in those countries. In Kashmir and in the Punjab the annual *Bombyx mori* silkworm is reared, and in these places also double cocoons are commonly seen. All double cocoons should be weeded out in selecting cocoons for seed.

SUMMARY OF CHAPTER VII.

1. *Court* occurs when silkworms are ripening. An exaggerated proportion of *court* worms indicates latent pebrine. Leaf from a new plantation or from a shady plot of land and insufficient supply of leaf cause *court*. Worms showing a great deal of *court* should not be used for seed.

2. *Gájlá* cocoons are formed in rainy weather. These are difficult to reel. They can be easily avoided. Cocoons spun in a well shut-up room in which a few maunds of quicklime or newly-burnt shells or limestone are kept do not become *gájlá*, even when the spinning takes place in rainy weather.

3. *Double* cocoons occur chiefly among European silkworms (the *Bombyx mori*). These cocoons cannot be reeled, but they should never be used for seeding.

CHAPTER VIII.

The Silkworm-fly and the Dermestes.

119. *Harm caused by the Fly.*—In 1887 an experiment was conducted at Berhampore to see if the parasitic fly of the silkworm (*Tricolyga Bombycis*) could be lured to lay eggs on earthworms, flesh-meat, dung and honey. All the substances experimented with, except the Mulberry, the Tusser and the Eri silkworms, failed to attract the fly to deposit her eggs. Quite recently the silkworm-fly has been observed as a parasite of the wild Tusser silkworm also. In the wild state this fly has so many enemies in the shape of birds, ants, etc., that it is rarer than wild silkworms. But where silkworms are protected from these enemies by being reared indoors, the parasitic fly is also protected from the same enemies. In Bengal and in Assam this fly is so common in the silk districts because it gets reared along with the domesticated silkworms. The fly breeds 8 to 9 times during the year. In Bengal and in Assam 7 or 8 crops of silkworms are also reared in succession every year, so the fly gets a ready host every time it makes its appearance, which helps it to multiply its species. In Europe, in Kashmir, in the Punjab, and in China and Japan, where only one crop of silkworms is usually reared during the year, this fly would not get to perpetuate its species. In Japan there is another species of the Tachinid fly, called the *Uji*. This

fly makes its appearance only at one season during the year, *viz.*, in May and June. In the district of Malda, in Bengal, another parasitic fly, called "*Kuji*," may be seen in small numbers in May and June. These hide themselves in the rearing basket, and afterwards lay eggs on the worms. This variety of flies has been noticed in large numbers laying eggs on silkworms at Kalimpong, near Darjeeling, also in May and June. Probably the *Uji* fly of Japan and the *Kuji* fly of Bengal are closely related. A silkworm fly may have as many as 200 eggs inside it. If one egg is laid on one caterpillar, one or two flies may kill about two to four hundred silkworms. But sometimes 20 to 25 eggs are seen on the same caterpillar. A whole crop may be ruined by two or three of these parasitic flies daily getting access into a rearing-room. In the cold season the parasite is less abundant. They go on multiplying fast from the spring to the end of the rainy season. After the nits or eggs are deposited by flies on the skins of silkworms, they hatch within a day, and the minute maggots wriggle their way inside the bodies of the silkworms. These maggots, eating into the substance of the silkworms, gradually attain their full size inside the worms and kill them. The fly-blown worms sometimes die before making cocoons. If they die in the chrysalis stage, the maggots come out of the cocoons, making little holes in them. These cocoons do not reel well; and they are quite useless for seeding, as a fly-blown worm can never turn into a moth. Fly-blown worms remaining dead in *dálás* for some time may give rise to flacherie among worms that are otherwise healthy. Whenever, therefore, the fly-pest does considerable damage to silkworms, flacherie also breaks out more or less severely. The fly-pest is an indirect cause of other diseases also, notably of pebrine, the germs of which are carried from one rearing-house to another by this parasite. On account of this pest, silk-rearers are often obliged to keep their rooms dark and completely shut up. Worms reared under such conditions naturally become weak and susceptible to all kinds of diseases. It is very important, therefore, to adopt remedies against this pest.

120. *Existing Remedy.*—That the fly-pest may not do much damage, cocoon-rearers of Bengal follow the practice of rearing silkworms every alternate *bund*. If this practice had been followed rigidly by every cocoon-rearer, the fly could not have done much harm. To take eight cuttings of mulberry leaf from the same fields successively during the year is not possible. It is, therefore, an excellent practice to rear silkworms one *bund* and attend to the mulberry field the next. But some rearers break this rule, and take two or three crops of cocoons in succession. When their first crop fails, they find a great deal of mulberry remaining over, and to use this up they go in for rearing another crop immediately afterwards. When this is done the maggots of the pest that accumulate in the village after the first crop, though mostly destroyed by ants and rats, produce a sufficient number of flies to ruin the second crop which the few rearers chose to take. These men thus derive very little profit by taking odd crops of cocoons, and they do a great deal of harm to the whole village during the third *bund*, when all the villagers go in for silk-rearing again. The flies of the first *bund*, getting ready host in the second, multiply enormously, and the second generation of flies do harm to the third, that is a regular *bund*, when all the silk-rearers in a village keep worms. If the general practice of cocoon-rearing villages was universally followed, the only source, ordinarily speaking, of the parasite would be the seed-cocoons brought to a village from a distant *joár* (silk-rearing locality). The few maggots thus imported into a village would do some, but little, harm to a regular cocoon crop.

121. *Destruction of the Parasite in Seed-cocoons.*—There is a way of destroying even those few flies that are imported into a locality along with seed-cocoons. Instead of bringing cocoons from a distant *joár*, rearers may adopt the practice of seeding the cocoons in that *joár* and bringing only eggs into their own *joár*. They will, of course, require to stay away from their villages a few days longer for seeding the cocoons; but if they can do it, they can avoid the pest most effectually. If a number of seed-rearing stations are established in every silk district

with Government aid and under Government supervision, arrangements may be made for despatch of eggs instead of seed-cocoons. But it is an excellent practice, which prevails in Bengal, to buy seed-cocoons after seeing how the worms ripen. If the system of buying eggs from seed-rearing establishments comes into vogue, there will be an opening for deception being practised by unscrupulous seed-rearers. There will not be so much fear if Government control is exercised on the working of the seed-rearing stations. If a sample of cocoons is sent every *bund* from each seed-rearing establishment to the Agricultural Department, an officer examining five or six days' old moths emerging out of these cocoons will be able to judge, even from a distance, if the working of the station is being faithfully carried on. This will be some check on deception being practised. If so much check is exercised over these establishments, cocoon-rearers may at times be put to loss by purchasing carelessly-reared or diseased seed from these establishments.

122. *Stringing of Cocoons.*—If seed-cocoons have to be imported into villages, they should be kept strung up with a concave vessel placed immediately under them (Fig. 6). The maggots coming out of the cocoons will drop into this vessel, and being unable to get out from a concave vessel, they can be easily collected and thrown into a tank for feeding fish with. Other advantages that are derived by keeping seed-cocoons suspended in strings like garlands have been described in a former chapter.

123. *Automatic Method of killing Flies.*—The three remedies for keeping down the fly-pest described above are not likely to be generally adopted by cocoon-rearers. An automatic method of killing the parasite may be found more acceptable. There should be only one entrance to the rearing-room. In front of this there should be a small room. This room should have two doors in two different directions. All these doors should be made of boards of wood only—that is, there should be no wire-gauze doors leading to the rearing-room. If this small room be used for microscopic work, there should be a glass window on another side. The roof of this small room

should be quite low, *i.e.*, only a cubit above head. Entrance into the rearing-room will have to be effected through this small room. If this small room is used for the storing of mulberry leaf, there should be one or two ventilators fitted with wire-gauze. In other words, there should be three doors in three walls of this room, and a glazed window and two ventilators in the fourth wall. The room being 4½ cubits in height, a fly getting into it accidentally when a person is going in or coming out can be easily killed. This room may be called the fly-killing room. In the rearing-room itself there should be large windows fitted with wire-gauze, and above each of them two ventilators also fitted with wire-gauze. These four windows and two ventilators should have glazed or panelled shutters inside. These should be kept closed on that side from which wind would find direct entrance. This rule should be observed in the case of the fly-killing room also. As the shutters should be closed on the side of the prevailing wind, it is an advantage to have them fitted with glass panes. This will make the room sufficiently well lighted, without admitting a current of air. The door of the fly-killing room which will be used for entrance should be kept closed with a latch, and outside this smoke should arise from burning cakes of cowdung. It is not necessary to have the smoke rising day and night from the fire: it is only when feeding or cleaning is done in day-time that smoke should arise in front of the outer door. The automatic arrangement for killing flies, presently to be described, should not be made in connection with this door. This would only induce the flight of the parasite in this neighbourhood, and a fly or two may get in occasionally when they get a chance of getting into the fly-killing room. If there is smoke at the entrance to the rearing-house, the flies will naturally congregate outside the windows and ventilators fitted with wire-gauze. The automatic arrangement should, therefore, be made in connection with the windows and ventilators. The basis of the arrangement to be described is water, to which kerosene oil has been added, being placed in a white and glistening vessel. These vessels are to be placed outside and immediately above the windows and below the ventilators, as the parasite is seen to fly about at some height from the ground.

The vessels, if convenient, should be white or colourless, and shallow or plate-like. A few drops of kerosene oil are to be put on the water in the vessels, and the water and the oil daily renewed. The smell of silkworms will come out strong only through the windows and ventilators fitted with wire-gauze and not though the doors of the fly-killing-room, which are made of boards or panels. The flies will naturally congregate outside the windows and ventilators. They will be repelled from the entrance to the rearing-room not only by the absence of smell, but also by the presence of smoke. Flying about in front of the vessels containing water and kerosene, they will be deluded into the idea of these glistening vessels being wide apertures into the rearing-house, and they will madly rush into them and get drowned. If kerosene oil is not put into water, the flies sometimes get out and escape; but the least touch of kerosene kills them. The dead flies should be taken out two or three times every day, and clean water and kerosene put in daily.

124. *The Fly-trap.*—We will now describe how the ventilators can be utilized as fly-traps. Fig. 13 gives a clear idea of the trap.

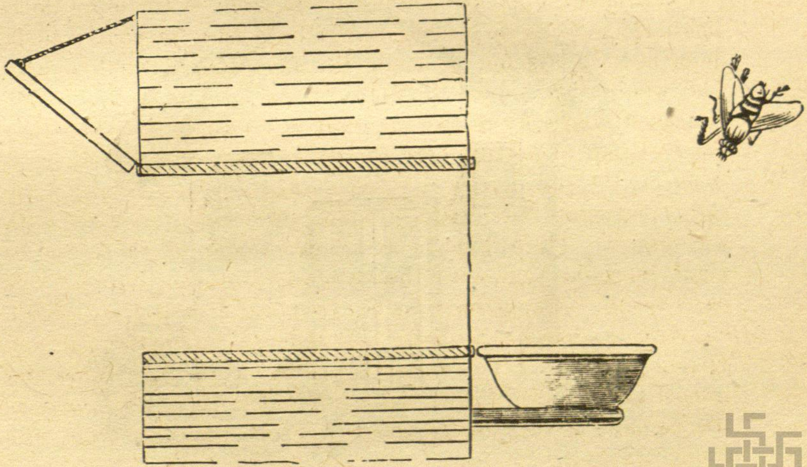


FIG. 13.—Combined Ventilator and Fly-trap.

It consists of a common wooden box, one end of which is sawn off and fitted with wire-gauze and the other end hinged with a drop-lid. This box is fixed into the wall of a rearing-room at a height of about 4 feet from the ground. The wire-gauze end of the box faces outside the rearing-room and the lid end inside.

When the rearing-room has to be fumigated at the commencement of a *bund*, or on muscardine breaking out, the shutter or lid should be dropped, in order to prevent the sulphur fumes escaping through the wire-gauze. When there are silk-worms in the room the parasitic flies get the smell of worms coming through the wire-gauze, and they also get a glimpse of them through this and the windows. A clean (and, if possible, white) vessel of water kept facing the ventilator immediately before it, and above the window (Fig. 14), to which a few drops of kerosene oil are added, attract the flies in large numbers, and it is seen that hundreds of flies come and get drowned in the vessel at certain seasons, while at all seasons a few will be found lying dead. Clean water and kerosene oil are put in, and the dead flies daily or occasionally thrown out.

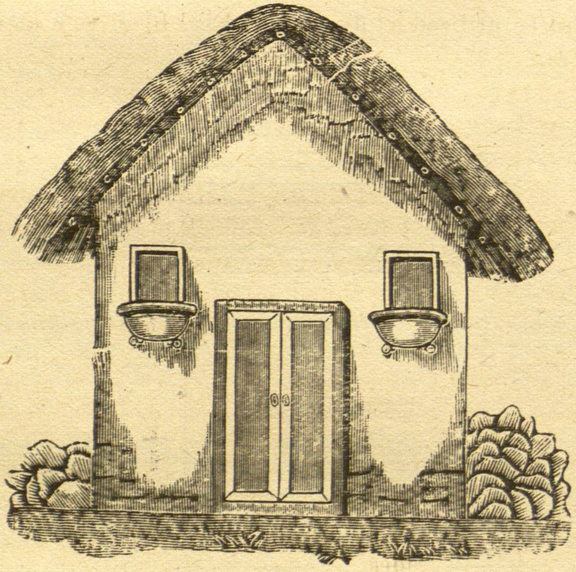


FIG. 14.—Gable end of a Model Rearing-room.

125. *Wire Boxes.*—The fly-pest proves most troublesome in odd *bunds,* when ordinarily no rearing of silkworms is done in the village. The methods described above for keeping the pest in check if exactly followed will enable one to rear silkworms even in these odd *bunds* without any difficulty. But if a very small quantity of worms only is reared for the purpose of keeping the seed up, an extra precaution may be adopted to avoid the pest altogether. The rearing-room fitted with fly-killing appliances, as described above, may be used for rearing the small quantity of worms; only, instead of keeping them on *dálás,* they may be kept in boxes fitted on all sides with wire-gauze. This extra precaution will do away with all fear from the parasite. At every season wire boxes may be used for protecting newly-hatched worms from being eaten up by mice, lizards, crickets and other pests.

126. *The Dermestes.*—The larval stage of this beetle (called *shorè-poká*) and the imago stage (called *kánkutur*) should not be mistaken for different insects. The *kánkutur* is analogous to the moth of the silkworm, and *shorè-poká* to the caterpillar. The cocoon-rearer does not suffer very much from this pest, but occasionally silkworms are eaten up wholesale by the larvæ and beetle of this insect. In November 1896 the principal cocoon-crop of the year in the Beldanga *joár* (Murshidabad) was ruined by this insect. From the time of hatching, the larvæ and the beetle began feeding on the silkworms; and although the insect was well known to the cocoon-rearers, they had never known them as devourers of silkworms. Those who have to keep cocoons stored in godowns have always known the damage caused by this pest. The *kánkutur* is a black, hard-winged insect (a beetle). It is about 20 times bigger than the rice-weevil and 20 times smaller than the ordinary cowdung beetle. The *kánkutur* or dermestes sometimes eat their way into a bale of silk, and cause damage. Ordinarily the dermestes eat their way inside cocoons and deposit eggs on chrysalides. The eggs hatching, little *shorè-pokás* come out, which thrive on the chrysalides, and become changed into *kánkuturs* in their turn. These, again, spoil other cocoons, and they may

go on doing more and more damage, so that one of these beetles may indirectly cause a great deal of damage. In Europe the larvæ of this beetle are considered the greatest pest in seed-rearing establishments. There microscopic selection of seed begins about a month after the eggs are laid. The larvæ eating up the moths, sometimes nothing is found in the cellules to examine. It is, therefore, considered essential to keep searching the cellules for the grubs. Those discovered are put in little bottles containing water to destroy them. In Bengal one must do the microscopic examination in eight or ten days after the eggs are laid by silk moths, so very little damage is done to seed-rearing establishments in Bengal by this pest. In cocoon-godowns it can be kept down by adopting a simple plan. To adopt this plan the cocoon store must be a well shut-up room. For every 40 maunds of cocoons stored in the godown a seer of carbon bisulphide should be kept unstoppered in a bottle with a narrow mouth. This substance exploding in contact with fire, a light or fire of any kind should on no account be taken near to the bottle. The strong and suffocating smell of this substance keeps out rats and all other pests, as well as dermestes, from the store. No harm is done to the silk fibre by this chemical. It does no harm to man if it is simply touched or smelt for a short time. In America it is commonly used for storing seed or grain from insect-pests of all kinds.

If seeding is done in a room separate from the rearing-room, this insect cannot find access into the rearing-room with seed-cocoons. If the rearing-room is properly fitted with wire netting, etc., the beetles cannot find access to the silkworms. The methods of protection recommended against the parasitic fly are, therefore, equally effective against the dermestes in protecting silkworms from their ravages, provided seeding is done and cocoons stored in a room other than the rearing-room.

SUMMARY OF CHAPTER VIII.

1. In each group of silk-rearing villages (called a *joár*), silkworms should be reared every alternate *bund*

by every villager to avoid excessive loss from the parasitic fly and the dermestes.

2. Seeding should be done, if possible, in the *joár* where seed cocoons are bought, and eggs instead of cocoons should be imported into villages to avoid the few parasitic flies and dermestes that are introduced with seed cocoons.

3. If seed-cocoons are brought, they should be strung up like garlands in some room other than the rearing-room, and a concave vessel (a *gámlá*) put underneath. The maggots of the parasite dropping into this vessel can be easily collected and destroyed. By this means also the parasites introduced with seed-cocoons are destroyed or kept out of the rearing-room.

4. A simple and effective method for destroying the parasite has been devised for automatically killing the parasites, and also helping the ventilation of the rearing-house.

5. Young worms reared in wire boxes can be protected from flies, spiders, crickets, lizards and rats, which destroy a large number of them when they are kept in *dálás*.

6. To protect cocoons in godowns from dermestes and other pests, the godowns should be firmly closed on all sides, and an unstoppered bottle of carbon bisulphide kept in each. A light or fire of any kind should not be taken near to this substance.

CHAPTER IX.

DISEASES OF THE MULBERRY PLANT.

127. *Nature of Tukrá.*—In Bengal the chief complaint of the mulberry plant is the disease known as "*Tukrá-lágá,*"

"*Tukrá-mará*" or "*Konkrá-dhará.*" When attacked with this disease leaves of the mulberry plant become curled up, and the tender shoots become swollen and leprous in appearance. Leaf affected with *tukrá* is avoided by silkworms; or if they do eat it in the absence of proper leaf, they take flacherie or grasserie. This disease of the mulberry plant does a great deal of harm to the silk industry of Bengal. From January to June it goes on getting worse and worse. At the commencement of the rainy season some mulberry fields do not show even a single leaf unaffected with *tukrá*. Plants affected with *tukrá* remain stunted in growth, and the leaves on them are more or less unsuitable for silk-rearing. From July to December the disease goes on abating. In the November *bund*, therefore, silkworms get to eat leaf most free from this disease, and their superior health at this season is partly due to this cause.

128. *Extent of the Disease.*—All the silk districts of Bengal are not equally affected by *tukrá*. In the district of Murshidabad the disease prevails to such an extent, that if it had not existed there could have been obtained at least a third more of mulberry and of cocoons. In Malda, Birbhum and Bogra very little damage is caused at present by *tukrá*. This is probably due to the intelligent way in which cocoon-rearers of these districts manage the cultivation of mulberry. The crops that are grown after thorough cultivation and manuring of the soil are naturally less subject to diseases. Crops growing on poor soil are naturally sickly and more susceptible to diseases. Animals also (including man) are subject to this law of being more susceptible to diseases in a weak state. Mulberry fields when properly cultivated, manured, and irrigated suffer very little from *tukrá*. It is also seen that large mulberry trees are not affected by *tukrá* in their higher branches. If a number of mulberry trees are grown in a field of ordinary Bengal mulberry, the leaves in the lower branches only will be noticed infected with the disease, but not those on the higher branches.

129. *Large Mulberry Trees.*—(1) The advantage of growing large mulberry trees has been described in connection with another disease also, *viz.*, grasserie, (2) Trees when

once grown up hardly cost anything for their maintenance. (3) Large trees are not affected by excess or deficiency of rainfall. (4) In other countries silkworms are reared with leaf gathered from the tree mulberry. It is only in Bengal that the shrub mulberry is maintained at an annual cost of Rs. 20 or Rs. 25 per bigha. There is only one advantage in maintaining the shrub mulberry: the *Chhottapalu* variety of silkworms can be reared much better on this than on any other kind of mulberry. If the Bengal mulberry is maintained, trees should be also grown all round the field and also round the rearing-house, and the leaf of the trees should be mainly relied upon. Cocoons reared by using the leaves of trees never cost so much as annas 8 per seer, and sold at this rate both the cocoon-rearer and the silk-reeler can derive profit from the industry. Bengal mulberry costs so much that cocoon-rearers cannot afford to sell their produce for annas 8 a seer. The propagation of large trees will tend to make the relations between the cocoon-rearer and the silk-reeler satisfactory, which at present is not always the case. (5) Another advantage of trees is that they do not require to be constantly guarded against cattle.[*]

130. *Causes of Tukrá.*—In May and June, when mulberry fields are full of leaves affected with *tukrá*, one watching the back of the leaves with attentive eyes will not fail to notice numerous minute insects moving about on them. These being nourished by sap circulating on the back part of the leaves, the circulation of sap goes on freely on one side and interruptedly on the other. This results in the leaves getting puckered up. The insects being more fond of the sap of tender leaves congregrate in greater abundance behind these leaves. In Italy an insect called *Diaspis Pentagona*, infesting large mulberry trees, causes a great deal of damage. These insects are larger than the insects causing *tukrá*, and they

---

[*] Of all the varieties of mulberry I have experimented with, the one I found best suited for rearing silkworms has been kindly identified by Dr. Gage of the Royal Botanic Garden, Sibpur, as *Morus Alba*, variety *Artopurpurea*. This is a fast-growing tree, the leaves of which are very large and thick, but at the same time smooth, tender and succulent. The internodes being very short, the quantity of leaves obtained is very large. This is the only tree-mulberry leaf on which the *Chhotapalus* thrive well.

infest branches, not leaves. The *naichá-poká* of the Bengal mulberry is probably the same as *Diaspis Pentagona* of Italy. The Bengal mulberry is rarely visited by the *naichá* insect: but the damage caused by the *tukrá* insect is considerable. The *tukrá* insect has been identified by Mr. Maskell, of New Zealand, as Dactylopius Bromeliœ, Bonche. The female of this insect when full grown looks like a pink-coloured seed of the sesamum, having a coating of white powder on its surface. When they are in this condition they have neither feet nor wings, and not being able to move about they remain hidden in the axils of tender leaves, surrounded with a little cottony secretion. The males of this insect when full grown have both wings and legs, and they are of green colour. The phenomenon called parthenogenesis, that is generation without the help of the male, prevailing in this species of insects, the male is very rare. The females lay eggs in the axils of leaves, where they lie hidden. The eggs hatching, insects scarcely visible with the naked eye come out and suck the sap of tender leaves. In the larval stage the insects are extremely agile, and when it rains they easily get washed out during their restless movements. Some hard-winged and green-coloured insects also devour them. In this way most of the larvæ get destroyed before they arrive at the stage in which they lay eggs. But they breed so enormously and so fast, and they are so well protected from destruction, moving about in the lower surface of leaves, that, notwithstanding the great numbers in which they perish, enough of them survive to show a continued increase of generation from January to June. From that time the continuous rainfall results in their destruction going on faster than generation. In September and October, when the stumps of the Bengal mulberry are cut away, very few *tukrá* insects remain to be weeded out. Even these few are nearly all removed with the stumps from the mulberry field. The very few insects that still remain on the field give a slight touch of *tukrá* to the November *bund* mulberry. From November to February the insects do not multiply so very rapidly on account of cold. From February to June the insects multiply so rapidly that *tukrá* spreads all over the field during this period.

131. *Destruction of Tukrá and Naichá Insects.*—The *tukrá* and *naichá* insects both belong to the same family as the *lac* insects (*Coccidæ*). Both the insects can be destroyed by the same method. The method should be adopted in the case of *tukrá* in September or October immediately after stumps are cleared away, but before the ploughing. The *naichá* insect does not appear in every mulberry field every year, as *tukrá* does. This method for destroying the *naichá* insect should be adopted whenever this insect makes its appearance. Equal parts of milk or whey and kerosene oil are to be put in a vessel and mixed well together with the help of a syringe, or the two substances may be put in a quart bottle and shaken together for about five minutes. Then 12 parts of water (*i.e.*, 24 times the quantity of kerosene oil or of milk) are to be added to the mixture, and the whole liquid put in an Eclair Vaporiser or spraying machine (Fig. 8), and applied on the mulberry field affected with *tukrá*. The operation should be conducted in the evening, that the insecticidal spray may not dry up too quick. After the stumps of mulberry are removed from the field, the few insects that will still remain in the field will lie loosely on the surface, and will easily get killed by the least touch of the kerosene emulsion. For killing the *naichá* insect, instead of using 24 parts of water, 100 parts of water should be used. If 24 parts of water are used, the leaves sprayed with the emulsion will get quite burnt up, which is, of course, harmful to plants. For *tukrá* the stronger solution may be used without any harm, as the application is made after the plants are cut away. The use of the spraying machine called Eclair Vaporiser is beneficial in two ways—(1) the emulsion comes out in the form of vapour, and it is impossible for an insect to escape it altogether if the spray is at all directed towards it, and (2) by its use a small quantity of kerosene oil can be used for spraying a large plot of land. One can with the help of this machine apply the emulsion to one bigha of land within an hour, using only 1 bottle of kerosene, 1 bottle of milk, and 24 bottles of water. It has been also said that by means of this machine rearing-houses

and their surroundings and rearing appliances can be disinfected without much trouble or labour. Indeed, this machine is so useful to agriculture in various ways that every cultivator should make an attempt to procure one. Standing crops, whatever they may be, when they are attacked by any insect or fungus pests may be treated with kerosene emulsion or sulphate of copper solution with the help of this machine, and saved from further injury. Messrs. Davenport and Company of Calcutta sell this machine for Rs. 50.

132. *Other Diseases.*—No other diseases of the mulberry are known in this country. In Europe the *Diaspis Pentagona*, which resembles the *naichá* insect, spoils mulberry trees, as mentioned already, by harbouring on branches. In Italy any proprietor of mulberry trees on which the *Diaspis* is observed may be compelled by law to take measures for its destruction. The object of compelling cultivators by law in this matter is that the evil may not spread and do harm to many people, though it may begin by doing harm only to individuals. Unless the multiplication of the insect is suppressed at once, it soon makes havoc of mulberry plantations, and spreads over a large tract of country. It is possible in this country also to abate the harm done by silkworm diseases, the silkworm-fly, and the mulberry disease by legislative measures.

133. In Europe the mulberry tree is subject to the attack of two other diseases, called, respectively, Fio-voulage and Pourridie. A fungus called Agaricus melleus growing and spreading underneath the bark of the mulberry tree gradually dries it up. European cocoon-rearers know when a mulberry tree begins to dry up quite accidentally that it is affected with Fio-voulage, and they take immediate measures to prevent the spread of the disease. The branch that dries up is denuded of its bark and then blackened with tar, the whole tree sprayed with sulphate of copper solution, and the bark stripped out, collected and burnt. Pourridie is caused by another fungus called Dematophora necatrix. The growth of this does not commence aboveground in branches, but underground in roots. The roots rot away, and the rotting gradually spreads higher

up. Mulberry trees growing in damp localities are sometimes affected with this disease. When a tree dies from this cause, the roots should be carefully dug up and burnt.

SUMMARY OF CHAPTER IX.

1. It has been ascertained that *tukrá* is caused by a minute insect, much smaller than the *naichá* insect, which also occasionally infests mulberry plants. These minute insects may be seen with the naked eye if the lower surface of a tender leaf affected with *tukrá* is carefully observed.

2. Both *tukrá* and *naichá* insects can be easily killed by an application of kerosene emulsion. Applied with an Eclair Vaporiser a small quantity of kerosene emulsion goes a great way; and in a very short time a large plot of land may be treated with the help of this machine. The following directions will be found effective for eradicating *tukrá:* after the mulberry crop is cut in the November bund, or after the mulberry stumps are cleared away in September or October but before cultivation is commenced the kerosene emulsion is to be applied. Equal parts of kerosene oil and whey or milk should be well mixed together by shaking or stirring. Then 24 parts of water (*i.e.*, 12 times the volume of the mixture of kerosene and milk) are to be added, which will make the emulsion of right strength for *tukrá*. One quart bottle of kerosene oil, one bottle of milk, and 24 bottles of water can be used for treating a whole bigha $(=\frac{1}{3}$ acre) of land if the Eclair Vaporiser is used. To kill the *naichá* insect of the mulberry plant 100 parts of water should be used instead of 24 parts.

CHAPTER X.

THE GRAINAGE.

134. *The Site to be chosen.*—It is the method of work that is to be followed in a *grainage* or seed-rearing establishment that has been described in all the previous chapters of this Part. It will be to the benefit of *general cocoon-rearers* also to imitate as much as possible the method of work recommended for a *grainage*. Only it will cost more if cocoon-rearing is done on the scientific principles recommended. Seed-cocoons fetch a much higher price than ordinary cocoons. It is for this reason only that well-to-do cocoon-rearers will find it more profitable rearing seed on scientific methods than rearing cocoons for reeling. Unfortunately there are not many well-to-do cocoon-rearers in Bengal. Those Bengal cultivators who have established *grainages* in Murshidabad, Midnapore, Rajshahi, Malda and Birbhum have been able only gradually to adopt the methods prescribed in this book. Obtaining satisfactory results by using the microscope, washing eggs, rearing-baskets and rearing-rooms with sulphate of copper water, and observing a few other rules, and finding the adoption of these practices profitable, and being able thereby to accumulate some money, they are now gradually introducing all the systems recommended in this book. The establishment of a *grainage* capable of producing the full quantity of seed-cocoons, as the result of selection with one microscope only, costs more than Rs. 2,000. A cocoon-rearer will find he is getting rich if he uses selected seed, nets, sulphate of copper, fly-traps (which also act as ventilators), kerosene emulsion and a few other easily available substances, and he can then remove from his own village, if it is a cocoon-rearing village, and set up a *grainage*, and make still larger profits. The following hints should be remembered in choosing the site for a *grainage*:—

(A)—It should be established close to a large tank, a river, or a marsh.

(B)—It should be surrounded by large trees. The planting of mulberry trees round a *grainage* is desirable.

(C)—It should be about one mile away from cocoon-rearing villages, filatures, or cocoon godowns.

(D)—It should be in some village where the labourer class is acquainted with the art of picking ripe worms, of handling moths, and of planting mulberry cuttings.

135. *Grainages in connection with Schools.*—If *grainages* are established altogether away from the silk districts, (1) the parasitic silkworm-fly, (2) the germs of silkworm diseases, and (3) excess of heat or cold may be avoided. But the disadvantages in having a *grainage* away from the silk districts outweigh the advantages. When a trained man starts the work in a new locality, he has to depend altogether on untrained labourers whenever he happens to fall ill. When this happens, the labourers usually mismanage and ruin the crop. It is extremely difficult to introduce cocoon-rearing industry among a peasantry who are altogether ignorant of the art. A person wishing to introduce the industry in a new locality requires the greatest patience, and to take a great deal of trouble in teaching the industry to the local peasantry. It is impossible to introduce silk-rearing in a new place without the help of rich men, capable of sympathising with cultivators and labouring with them for one, two, or three years continuously. There is another means by which silk-rearing can be introduced in a new locality. In France, in the Department of Midi, there are about forty normal schools for young men and young women. The scholars of these forty normal schools are obliged to do silkworm-rearing after microscopic selection of seed for two months in the year. No other technical subject is taught in the normal schools of this Department. There are great facilities in France for technical instruction; but no other subject, besides rearing of silkworms for seed, is taught compulsorily both to boys and girls along with a general course of education. That the " seed " rearing industry is considered of very great importance in France may be judged from the system of education which prevails in that country. In this country, also, sericulture is likely to make rapid strides if the

subject is practically taught in a few schools. Village schoolmasters may set an example to cultivators by rearing silkworms on rational principles for seed, and by imparting a course of instruction to their boys.

136. *Respective Duties of High-caste Men and Cultivators.*—When a person belonging to an upper class takes to agriculture, he finds it a more expensive industry than actual cultivators find it. Seed-cocoons fetch twice as much price as ordinary cocoons. So when a high-caste person wishes to take up the industry, he should think only of producing "seed." The capital required to establish a *grainage* is also, as a rule, beyond the means of ordinary cultivators. The knowledge and foresight required for producing healthy seed are not easily attainable by cultivators. But the industry is not so complex that boys of cultivators, reading books on the subject for one or two years and frequenting a *grainage* cannot master it completely. To rear some cocoons only requires hardly any capital. By getting a few mulberry trees grown in their fields and rearing cocoons, a family of cultivators may make larger profits than by ordinary agricultural pursuits. In course of time these cultivators will be able to lay by sufficient money to establish a *grainage.* When a cultivator establishes a *grainage,* he can work it much cheaper and get more successful results than a high-caste man can. When a person introduces the silk-rearing industry in a new locality, whether he be a village school-master or a man belonging to some upper class, he should always remember that once it is properly introduced among the peasantry, they will be able to push it on much more rapidly. The gentlemen who are at present trying to introduce the industry into new localities very often make some mistake or other, and incur loss. One rarely hears of the silkworms of a professional rearer being destroyed by ants. High-caste men often forget to notice whether the glue round the posts of *máchâns* has dried up, and so they very often complain of silkworms having been spoilt by ants. Long before sunrise the professional cocoon-rearer finishes giving his worms the first feed. A high-caste man's silkworms usually get their

first feed about 8 o'clock in the morning. The professional cocoon-rearer never starves his worms during storm or rain, or a domestic calamity, or a Puja festival. A high-caste man's worms sometimes have to go with one or two feeds, or none at all. A high-caste man often neglects to follow methods he knows. A cultivator scrupulously carries them out if he can afford to do so. The rearing-house of a cultivator is usually kept clean and tidy. The high-caste man usually leaves his silk-rearing house in an unclean state. The cultivators who have already established *grainages* are all raising very good seed, and benefiting thousands of cocoon-rearers. The gentlemen who have started *grainages* have not been able as yet to make the experiment pay its own way, and the benefit derived by others from their experiment is as yet of a very limited nature. A high-caste man should never imagine that, because an industry pays cultivators very handsomely, he can make it pay equally well also. A gentleman is likely to be disappointed if he undertakes the experiment, not with the object of benefiting the cultivator caste, but of making large profits himself. Agricultural improvements prove lasting and efficient when they are introduced among actual cultivators. Other agricultural pursuits may be successfully carried on by high-caste men, but it is almost impossible for cocoon-rearing to be successfully carried on by them. Rich men and men belonging to the higher castes depend entirely on hired labourers. Ordinary agriculture does not suffer if by any accident labourers cannot be had for a day or two. Agricultural crops do not require human assistance about four times a day for making use of air and sunlight and moisture of the soil, which help their growth. The ox, the buffalo, the horse, and other large-sized animals also are not so hopelessly dependent on man, and when they cannot procure sufficient food, or when they are attacked with disease, they can express themselves by cries of wail. If servants accidentally make a mistake in putting leaf on one among several *dálás* of silkworms for a day or two, the worms cannot attract the attention of the master by any cry or squeak. It does harm to silkworms if leaf is given to them too soon after a moulting period. The master is not likely to be able to detect when servants recommence feeding the worms too soon after a moulting period. Messrs. Lister & Co. have been trying to rear silkworms on a large scale in the North-Western Provinces of India by the employment of gangs of hired men. Almost every crop fails through some mismanagement or other. The Company have now come to recognize that it is possible to carry on the industry only by getting *raiyats* to rear silkworms and sell cocoons to the Company, to be reeled in the Company's filatures, but that it is not possible to get silkworms reared by hundreds of hired labourers even under European supervision. The capitalist can make plantations of mulberry trees, buy cocoons from peasants, and make profits by reeling silk in large factories. But a rich man will be disappointed with the profits, if any, of cocoon-rearing. "*Petites magnaneries, grands filatures*" is a proverb expressive of vast experience and wisdom.

137. *Fundamental Principles of Sericulture.*—Professor Maillot, a great authority on sericulture, has laid down the fundamental principles of sericulture in one striking sentence in his work entitled Lecons sur le ver a soie (page 167). The substance of this sentence is—

(1) Each house should rear only a small quantity of silkworms.
(2) The greater the number of houses engaged in sericulture, the better it is for the industry.
(3) Silkworm-rearing should be done with healthy seed, and
(4) With leaves gathered from large plantations of mulberry trees.

138. *Silk-rearing should be done by all Ordinary Cultivators.*—The proverb quoted above and the four fundamental principles of Professor Maillot should be borne in mind by every one intending the practice of sericulture. One wishing to start a seed-rearing establishment on a practical scale should not think of carrying on other agricultural practices at the same time. But for ordinary cultivators to devote

their whole time to the growing of silk is not proper. Man cannot live by wearing silk garments alone. The cultivator, by producing various kinds of things needed by man, renders great benefit to human society, and he should never cease to grow many kinds of crops. Indeed God's laws are so wonderful that man is not able to grow only one kind of crop in one tract of country for an indefinite period of time with profit without making that tract of country gradually more and more unsuitable for growing that particular crop. But ordinary cultivators should have some knowledge of sericulture, because, (1) sericulture is more profitable; (2) sericulture is helpful to ordinary agriculture; and (3) sericulture is admirably suited for the women of this country, many of whom cannot work out of doors on account of the *zanana* system which prevails in this country. Cultivators will soon come to know their mistake if they do nothing but sericulture all the year round and neglect ordinary agriculture. If large numbers of one species of animals only, whatever it may be, are reared in one locality, that locality gradually becomes unhealthy for that particular species of animals. That the silkworm is also subject to this general law should be borne in mind. In some villages in Bengal every cultivator goes in for rearing silkworms. On entering a village of this kind, one cannot fail to perceive a strong smell, which is significant of silkworm-rearing. This smell cannot be healthy to silkworms. The germs of silkworm diseases, described in the earlier chapters of this book, which are abundantly present in the air, which thus smells strong, make the village gradually unsuitable for silk-rearing. That it is possible for individuals to rear silkworms time after time successfully in the same locality by adopting certain special measures is not denied. Indeed, it is necessary in certain *grainages* to rear cocoons for seed all the year round, for keeping up seed of particular kinds of silkworms, out of their proper season.

139. *Method of work to be followed in a Grainage.*—A *grainage*, however isolated it may be, should be disinfected every *bund*, both inside and outside; all the appliances also purified, the pierced cocoons sold as soon as seeding is over,

and the litter put in a pit. If all these precautions are not carefully observed each time, the locality may get infected, and pure seed will not be produced.

140. *Additional disadvantages in having Grainages outside the Silk Districts.*—It has been already said that *grainages* should be established at some distance from silk-rearing villages, but that they should not be established too far away from such villages. Some of the disadvantages of having *grainages* too far removed from silk-rearing localities have been already described. There are two others that should be mentioned:—(1) The disadvantage in the disposal of seed, and (2) the comparative uselessness of the institutions as educating agencies. Silkworm-rearers want to see the worms ripening before they buy seed-cocoons. Diseases show themselves chiefly at the time of ripening, if they do show at all. If a lot of silkworms ripen without showing any signs of disease, it is reasonable to conclude that the cocoons spun by them will not prove bad if used for seed. The custom which prevails among silk-rearers in this respect is therefore very laudable. *Grainages* situated within easy distances from silk-rearing localities can be visited by cocoon-rearers, before they buy seed, at the time of ripening of the worms. *Grainages* when situated outside the silk districts, cocoon-rearers have to depend on the seed coming safe by post, which sometimes it does not, and they have also to trust to the word of the seller of the seed that the worms had ripened well. Business transactions do not get on smoothly under such conditions. (2) Cocoon-rearers going to *grainages* for the purpose of buying seed can see for themselves the rational methods followed by their fellow-castemen in raising healthy seed, and they will naturally want to improve their own methods of cocoon-rearing by imitating what they see in *grainages*. *Grainages*, when situated outside the silk districts, can have no effect in improving the methods of sericulture prevailing in the silk districts.

141. *Methods to be imitated by Ordinary Cocoon-rearers.*—Cocoon-rearers generally can adopt certain improved methods

by watching those practised in *grainages.* These improved methods should be recommended to silk-rearers by seed-rearing houses on printed sheets of paper, the blank side of which may be used for moths to lay eggs on. Seed-rearers should be always anxious that good results should follow the use of seed brought from their establishments. If sheets of instructions are distributed along with eggs, they are likely to prove an excellent advertisement for the *grainage.* The methods that may be imitated by all cocoon-rearers are described below:—

(1) *Selection of Seed.*—All cocoon-rearers should know all those methods of judging seed which do not require the use of the microscope. These are—

(*A*) If smelling a lot of cocoons, one finds the smell very disagreeable and inducing fits of sneezing, these are probably not suitable for seed.

(*B*) If 10 or 15 cocoons out of a lot are cut open, and a few five or six days' old chrysalides inside them are found dead, the use of these cocoons for seed may cause loss. But if the death of the insects be due to the attack of the parasitic fly, it should not be taken as indicative of disease.

(*C*) If the eggs are wanting in gum, *i.e.*, if they drop off loosely when the *dálá* or sheet of paper on which they are laid is turned upside down, the worms from these will probably die off.

(*D*) Moths retaining eggs inside them and laying very few are probably diseased.

(*E*) If the eggs are not laid in compact circles, but in a scattered manner, they are probably diseased.

(*F*) If moths die within a day or two after laying eggs, they are probably diseased.

(*G*) If the moths, instead of being dark-coloured and having properly expanded wings, appear white or pale and deformed, and, when dead, if the joints give way, and if a little fluid taken out of its body instead of being white is found to be of any other colour, probably these moths are diseased.

(*H*) The worms which become uneven in size in the hands of a professional cocoon-rearer are probably full of pebrine.

(*I*) If the body of a silkworm taken out of a ripening lot feels unyielding, and if when it is thrown on its back it immediately turns round; in other words, if it appears quite vigorous, and if dead worms are not easily noticed on spinning mats, the cocoons spun by such worms may be used for seed.

(*J*) Worms eating up leaf quick, and spinning cocoons readily when they are ripe, may be chosen for seed.

(*K*) The *Barapalu* worms which show a considerable proportion of black caterpillars, and the *Nistári* worms which do not show many *Naris* (markless caterpillars), or do not show these at all, are probably suitable for seed.

(*L*) The *Nistári* worms which show a proportion of *Sonámukhi* caterpillars (that is, caterpillars which look greenish at the time of ripening), and which have deep-black marks on them, may prove a valuable acquisition if they are kept for seed.

(*M*) The worms which do not show any dead specimens in their litter, even when they are ripening, are likely to yield healthy seed.

(2) *Uncertainty of Naked-eye Appearances.*—When a person selects seed guided by the above-mentioned principles, he is not to suppose that the seed is bound to be good. When on examining moths five or six days' old under a microscope one does not find any germs of pebrine, or does only in a very few specimens, that is in less than 10 per cent. of the moths examined, the eggs laid by them should be considered undoubtedly good. These eggs, reared in a disinfected room and with disinfected appliances, are bound to give good results if the rearing is done with ordinary care. It has been also seen that judged by the above naked-eye appearances, a lot of seed may be pronounced very poor, but judged by the microscopic test, it may be pronounced free from pebrine. When this happens, good result is obtained from such seed. Indeed, the only certain test whether eggs are healthy or not is the presence or absence in a marked degree of pebrine corpuscles in moths at least five days' old which have laid the eggs in question. For cocoon-rearers generally it is safest, therefore, to rely on seed raised in *grainages*. To make quite sure of the seed

bought from *grainages*, one can get a number of five days' old moths examined by microscope in another *grainage*. If on examining 10 moths only 1 is found with pebrine corpuscles, the rearer should feel no hesitation about keeping this seed, but he should get the rearing-room and appliances and also the eggs washed with sulphate of copper before commencing the rearing. If on getting a sample of moths examined a rearer should see almost every one of the 10 specimens showing pebrine, he should have no hesitation in destroying the seed, and looking out for fresh seed or selling mulberry leaf, instead of running the risk of losing his crop.

(3) There should be a number of large mulberry trees in the immediate vicinity of the rearing-house. These will be a protection against grasserie and *tukrá*. Under the shade of trees in the cold weather and at night it is comparatively warmer, and in the hot weather and in day-time it is comparatively cooler. Evenness of temperature is one of the principal conditions of successful rearing.

(4) Rearing-houses situated close to large basins of water may be used for rearing silkworms in January and May.

(5) Prevailing winds must be avoided, as these cause grasserie and flacherie.

(6) Cocoons and silkworms, or full-grown silkworms and younger silkworms, should never be kept in the same room.

(7) Pierced cocoons should never be stored in the rearing-room.

(8) It should be seen that the room and the verandah in front, as also the *dálás*, be all thoroughly *leped* before the hatching of the eggs takes place. No un-*leped dálás* and no *chandrakies* should be kept in the rearing-room, or in front of it, after the eggs have hatched.

(9) Worms should be fed at exact hours every day. The morning feed especially should be finished daily before sunrise. Young worms benefit by four or five feeds *per diem*, as they ripen in that case in a shorter time and become stronger ; but after the fourth moult, only the three regular feeds should be adhered to, though each time a liberal quantity of leaf should be put on the rearing baskets.

(10) Newly-hatched worms should be given tender leaf finely chopped up. As they grow larger in size, they should get leaf less and less tender. If the same lot of worms are fed from first to last on leaf from the same plot of land, they would naturally get leaf more and more mature as they grow in size. When a new piece of mulberry land has to be sought in finishing up the rearing with, it should be seen that the leaf of this plot is a little more mature than that on which the younger worms were being fed.

(11) Young worms should be kept very sparse on *dálás*. It does not do such harm keeping worms at the last stage thick on *dálás*.

(12) Litter should never be disturbed inside the rearing-room. The cleaning of *dálás* should be done either in the fly-killing room or in a corner of the verandah. The sweeping of the rearing-room should be also done so gently that dust may not be raised.

(13) Eggs should be laid by moths on sheets of paper. The sheets of eggs should be afterwards washed with sulphate of copper water (1 *chitak* of powdered sulphate of copper being used with 12 seers of water). When worms have passed the fourth moult, an ounce of sulphur should be daily burnt in the rearing-room.

(14) Should a worm dead of muscardine be noticed in the litter, all the *dálás* should be cleaned thoroughly without loss of time, the room *leped* with sulphate of copper water, and half a seer of sulphur properly burnt inside the room immediately afterwards.

(15) There should be two or three ventilators fitted with *chiks* and shutters in every rearing-room. In the hot season and the rainy season these should be kept open day and night, and even in winter one of them should be left open (Fig. 13).

(16) Two or three maunds of freshly-burnt shells or limestone should be kept in a shut-up box always in readiness in the rearing-room. At the last stage of the worms, if it happens to rain heavily, the box should be kept open. The quicklime absorbing the moisture of the room, grasserie and flacherie are both kept in check.

(17) If it rains when the worms are ripening, and *gájlá* cocoons are feared, the *chandrakies* with ripe worms should be kept in a well shut-up room and a box of quicklime kept open inside this room. This will result in properly reelable cocoons being spun. All cocoon-rearers should be familiar with this simple method of avoiding *gájlá* cocoons.

(18) If it rains continuously for three or four days, and no easy means is forthcoming for killing the cocoons before the moths come out and spoil them, one pound of carbon bisulphide may be used for every four maunds of green cocoons for killing these cocoons. This chemical should be poured on a plate or some other shallow vessel, and introduced into the bottom of a *kuthi* or *jálá* used for storing grain. A basket should be put on the plate of carbon bisulphide as a covering, and the *kuthi* or *jálá* should then be filled up with live cocoons, and the mouth of the *kuthi* firmly closed with the help of a *sará* (concave earthen vessel) and cowdung paste. The vapour of carbon bisulphide kills the chrysalides in five or six hours. A light or fire of any kind should never be brought close to this chemical, as this may result in an explosion; so the killing of cocoons with this substance should be done in daylight.

(19) In Chapter VIII, the method described for killing the parasitic fly could be easily followed by the ordinary cocoon-rearer.

(20) Silkworms should not be reared in two *bunds* successively in the same village, and all the rearers of one village should procure seed at one and the same time.

(21) Seed-cocoons should be strung up like garlands, and underneath there should be a *gámlá*.

(22) Silkworm-rearing should not be done in those seasons when the heat or cold is too intense. If worms have to be reared for keeping up seed at these seasons, only small quantities should be reared.

(23) It is not quite impossible for the ordinary cocoon-rearer to use the cleaning nets which they see in *grainages*.

(24) The droppings of silkworms and the remains of the mulberry leaf on *dálás* should never be kept in a heap inside

the rearing-room or in its immediate neighbourhood for any length of time. Daily the litter should be removed to a distance and thrown into a pit to be rotted into compost, or it should be allowed to be devoured by cattle. It should never be allowed to get dry. The litter or the cowdung obtained from it does no harm if it is applied to land after it has been rotted for seven or eight months.

142. *Full-sized Grainage.*—A *grainage* on a fairly large scale can be conducted even when there is only one microscope used. To make full use of a microscope, two men at least should learn the microscopical work. It is difficult to conduct even a small *grainage* unless there are at least two trained persons employed in it. In the hot season one gets only two or three days every *bund* for doing microscopic selection and disinfection of appliances. If one trained person only is employed, he may happen to be ill at the time of microscopic selection, or some other accident may prevent his doing the work during those two or three days, and the men buying seed next time from the *grainage* may lose confidence in this *grainage* for ever, as a consequence of this misadventure. As one microscope and two trained men are necessary even for a small *grainage*, one should from the very first have the idea of setting up a full-sized *grainage* eventually, and plan his arrangements accordingly in procuring land or in building rearing-houses. One man working in the morning and the other in the afternoon with the same microscope can select enough of seed to rear 10 maunds of seed-cocoons per *bund* in the hot season, and 20 maunds per *bund* during the cold season. In establishing a *grainage*, one should therefore have the idea from the first of providing for the rearing of 20 maunds of cocoons. The *mácháns* should be constructed to hold 10 *dálás* only, one above another, and not 16. In other words, instead of providing 20 *máchâns* for rearing 20 maunds of cocoons, 32 *máchâns* should be provided for. Eight *máchâns* being erected in each room, four rooms will be required. If one cannot afford to have four rooms from the first, one room and one fly-killing room should be provided. The same

fly-killing room may be afterwards utilized for three other rearing-rooms if these latter are built against the three free walls of the fly-killing room. When all the four rooms have been built, the *grainage* may be looked upon as a full-sized one. The floor of the rearing-house should be raised at least one cubit from the ground. Fig. 15 will show how four rooms can be built round the same fly-killing room. The figure is explained below:—

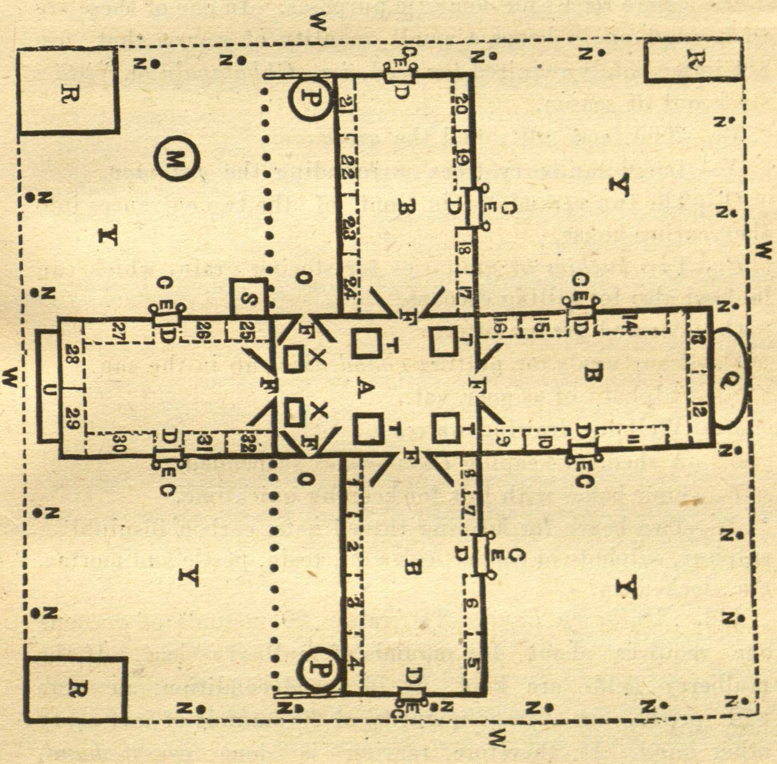


FIG. 15.—A Model Grainage.

A.—Masonry-built fly-killing room. This room, if possible, should be two-storied, the upper story being used for storing cocoons and killing them, when necessary, with carbon bisulphide, also, for exposure of spinning cocoons to quick-lime, and for microscopic examination.

B.—Four rearing-rooms against the four walls of the fly-killing room.

C.—Windows, with combined fly-traps and ventilators.

1 to 32.—Spaces for *máchâns.*

D.—Glass shutters to windows.

E.—Wire-gauze sashes to windows.

F.—Six doors of the fly-killing rooms, upper portions of which are glazed to admit some light to the fly-killing rooms.

R.—Spare rooms for domestic purposes. In one of these are to be kept up in boxes a small quantity of worms that are not immediately required for seed, *i.e., Chhotapalu* or *Nistári* stock out of season.

W.—The fence all round the *grainage.*

N.—Large mulberry trees surrounding the *grainage.*

O.—The two verandahs in front of the two entrances into the rearing-house.

P.—Two *kuthies* or granaries for storing grain, which can be used also for killing cocoons.

Q.—Covered pit for litter.

Y.—Four yards for putting *chandrakies* up in the sun.

S.—Sulphate of copper vat.

M.—Well for drawing water.

U.—A shed for keeping *chandrakies* suspended.

T.—Four boxes with lids for keeping quicklime.

X.—Two boxes for keeping thread nets, carbon bisulphide, sulphur, sulphate of copper, colza oil, resin, pestle and mortar, etc., locked up.

143. *Mulberry Land.*—To raise 20 maunds of cocoons one requires about 40 maunds of mulberry leaf. If the mulberry fields are kept up in good condition, an acre will produce an average quantity of 60 maunds of leaf every other *bund.* If, therefore, rearing is done every *bund,* 40 bighas (13 acres) of mulberry land will be required for a full-sized *grainage.* As only 10 maunds of seed-cocoons should be reared every *bund* during the hot and rainy months instead of 20 maunds, leaf can be sold to outsiders during these *bunds.* Sale of leaf can take place only when a *grainage* is situated within a few miles of silk-rearing villages.

A *grainage* so situated can also buy mulberry leaf from neighbouring villages if the supply happens to fall short. These two advantages are not within reach of grainages situated outside the silk districts. If leaf has to be bought, one precaution should be always taken. Leaf from fields manured with silkworm litter should never be purchased for the *grainage*. A field outside a village, and not one situated inside it, should be selected when leaf has to be purchased.

144. *Large Mulberry Trees.*—If these are available, 200 full-grown trees will yield 400 maunds of leaf. With 800 full-sized mulberry trees, one can take 8 crops of cocoons (20 maunds each time) annually, stripping each tree twice during the year. To get 13 acres of Bengal mulberry planted, it may cost as much as Rs. 2,000. To propagate 800 large mulberry trees patience alone is required. The expense for planting 800 trees is insignificant. Eight hundred young plants may be propagated in a nursery less than $\frac{1}{20}$th of an acre in area. These transplanted about 24 feet apart will cover a space of about 13 acres, or 40 bighas. Cultivators working with their own hands have to spend as much as Rs. 20 per bigha to establish the Bengal mulberry, and as much as Rs. 15 per bigha annually to maintain it afterwards. High-caste men who hire labourers spend as much as Rs. 40 to Rs. 50 per bigha in planting Bengal mulberry, and Rs. 25 annually in maintaining it. To start silkworm-rearing after propagating large trees means such patient waiting that it is difficult to induce any one to follow this procedure. There are two ways of avoiding the dilemma, of either spending a large amount of money in planting Bengal mulberry and beginning cocoon-rearing within three months after planting, or starting the rearing five years after planting. The first is, to use the whole of the 40 bighas of land from the first for ordinary agricultural crops, planting mulberry trees at regular intervals also from the first, and when these trees are grown up, to give up ordinary agriculture and to establish the *grainage*. Planting of mango and jack fruit trees is commonly done in rice fields when one wants to convert

them into orchards. Even when the trees are grown up, the land in between can be cultivated. This land will not do for ordinary agricultural crops when the trees are planted 24 feet apart, as the shade will be too great. But it is to the interest of the mulberry trees that the underlying land should be kept in cultivation. Land left without cultivation and overgrown with weeds harbour insect pests of different kinds. If any of these happen to injure mulberry trees, they will go on increasing and ultimately ruin the trees. The land in between the trees can be utilized for growing turmeric, ginger, pineapples, *pippul* (*Piper longum*), groundnuts, and seedlings of areca nut and cocoanut palms. The second way of avoiding the dilemma is to grow the mulberry trees close together at first, *i.e.*, at a distance of 3 feet instead of 24 feet. After the plants have been removed from the nursery and planted 3 feet apart in fields four or five months only may be allowed to expire before silkworm-rearing is commenced by using all the leaves that can be gathered within 6 feet from the ground, and cutting down all trees that remain stunted in growth. In this way all the trees that will grow vigorously will be at first encouraged to grow, and all poor trees and all the lower branches and low growing bushes will be used for silkworm-rearing. When the trees get too thick, they should be gradually thinned out, until, after five years only the best trees will be left remaining standing 24 feet apart. If the plantation is worked on this system, time and land will not be wasted, and experience will be gradually acquired in the working of the *grainage*, and some income also may be derived.

145. *Despatch of Seed.*—It is important to despatch silkworm eggs very carefully from a *grainage*. Delay in the despatch usually results in the eggs hatching on the way, and if they are sent by post in the hot season, they usually turn pink in colour, and are liable to take flacherie afterwards, or get all together killed by the heat. Arrangements should be complete for despatching seed on the day after the eggs are laid by post or by some other means. Eggs for rearing two or

three maunds of cocoons only can be sent in paper parcels, the eggs being deposited on sheets of paper, cotton-wool wadding being put in between the sheets when folding them up, and the parcels left open at the two ends. If a large quantity of eggs have to be sent out, they should be sent in several parcels. In one paper parcel there should not be sent more than four or five sheets of paper. If several sheets of eggs have to be sent in the same parcel, they should be put in a wooden box containing large holes on all sides. The sheets of paper can be strung together, and the pieces of string with the sheets of paper hanging loosely down may be tied to the lid of the box, and the box sent away afterwards. Eggs should not be sent from one place to another in parching hot weather. It is safer sending cocoons at such seasons. Cocoons should be kept in a damp room in such weather, or else the eggs laid by moths coming out of them may fail to hatch. If moths and eggs have to be sent to a distance for microscopical selection, the moths should be placed on pieces of paper 7 inches by 4 inches covered up with little earthen cups, leaving half the space of each piece of paper free. After the moths have finished laying eggs, *i.e.*, a day or two after, the moths are to be folded up at the free ends of the pieces of paper and despatched. In this way each moth will be sent with its own laying of eggs separately. The folding of the pieces of paper should be so well done that the moths may not crawl out of them, but at the same time that they may not be crushed to death. The eggs and moths may also be sent in separate pieces of paper, in which case the two pieces must be numbered correspondingly.

146. *Exchange of Seed.*—In a *grainage* there should be kept at all times various kinds of silkworm eggs. The proprietor of a *grainage* should never depend on village seed or seed from another *grainage*, as much disappointment is sometimes caused when one has to go elsewhere for a particular kind of seed. It is in September and October that *Chhotapalu* cocoons are required for seed for the November *bund*. To make sure of *Chhotapalu* during those months, the *graineur* should keep a *káhan* or two of *Chhotapalu* worms every *bund* throughout the year. To select 20 or 25 *Chhotapalu* moths every *bund*, and to rear the eggs in wire boxes in a corner of a room used for domestic purposes, is a simple matter. If this is done, one is never

in trouble in September for *Chhotapalu* seed. It should, however, be borne in mind that exchange of seeds is beneficial. In other words, a *grainage* situated in laterite or rocky soil should import 20 or 25 moths and their eggs from another situated in alluvial soil, in exchange for the same numbers of moths and layings of eggs, every now and again. This exchange will benefit both *grainages.* In the same way, a *grainage* situated in the plains should bring down a few moths and eggs from another situated on a hill, in the beginning of the rainy season, in exchange for the same number of moths and eggs. This exchange also will benefit both the *grainages.* However beneficial this exchange may be, one *grainage* should never be hopelessly dependent on another *grainage.*

147. *Expense and Outturn.*—

CAPITAL OUTLAY.

	Rs.
For getting mulberry plants propagated in a nursery 5 bighas in extent (planting being done about 9 inches apart)	200
Transplanting them a yard apart in fields (40 bighas)	200
[To protect 40 bighas with ditches and fences may cost Rs. 400, but there should not be the necessity to protect so much land from cattle.]	
One year's wages of four gardeners employed to look after the young trees	288
Posts and string for any trees that may require to be propped up straight	50
Cost of getting a *pucka* fly-killing room, 16 cubits long, 12 cubits wide, and only 5 cubits high, with an upper storey for storing cocoons	500
Cost of building four mud-walled rooms, 22 cubits long and 12 cubits wide, against the four walls of the fly-killing room ...	400

	Rs.
Cost of getting a sulphate of copper vat lined with Portland cement	10
Two *kuthies* or granaries	8
320 circular *dálás* (3½ cubits in diameter) ...	100
150 *chandrakies*	150
640 pieces of thread nets	250
A microscope	75
400 slides	2
One Eclair Vaporiser	50
One maund of sulphur	6
Half a maund of sulphate of copper ...	9
10,000 earthen cups for covering moths ...	20
Resin and oil	2
10 lb. of carbon bisulphide	10
8 maunds of quicklime and 4 boxes for keeping the lime	20
A pair of pestle and mortar	1
Two boxes for storing the small things ...	2
20 perforated wooden boxes for despatch of seed	10
Cloths for covering leaf, knife for chopping leaf, hook for cutting mulberry bushes, bamboos for *mácháns*, string, etc. ...	37
Total expense for the *grainage* ...	2,400

148. *Annual Expense.*—For rearing 20 maunds of cocoons during three seasons and 10 maunds during the remaining five seasons (*bunds*), ten permanent labourers will be found sufficient. When the worms will arrive at the last stage, extra hands will be required, and when the worms begin to ripen, women and children will have to be employed to pick up ripe worms. Rupees 4 for every maund of cocoons will be ample for employing extra labour. The ten men permanently employed can help the four *malis* in the mulberry fields for three or four days after the cocoons have all spun, three or four days after the eggs have been laid, and eight to ten days when the worms

are young. Propagating large mulberry trees costs very little in labour. The two or three trained men who may do the microscopic work and who will look after the whole establishment have been assumed to be the proprietors of the *grainage.* Their wages have therefore been left out of account in the preceding and also the following statement:—

	Rs.
Pay of ten permanent labourers	720
Pay of four men employed in the garden	288
Wages for extra hands, at Rs. 4 per maund for 110 maunds	440
Purchase of resin, oil, sulphur, and repairs	52
Total annual expense	1,500

It has been already hinted that it is better to develop a full-sized *grainage* gradually than to build it all at once. This means that the expenditure of Rs. 2,400 need not be all incurred in one year, but distributed over a period of five or six years; and instead of producing over 100 maunds of cocoons from the very first, 10 to 15 maunds can at first be raised, and after five or six years the full quantity. In this case the annual expense also will not come to Rs. 1,500. If no silk-worm-rearing is done at first, but ordinary agricultural crops raised, and mulberry trees planted 24 feet apart, hardly any expense will be incurred for the *grainage* for the first five years. If a *grainage* is started all at once in a place where large mulberry trees are at hand, the initial outlay will come to about Rs. 1,700 instead of Rs. 2,400; that is, about Rs. 700 will be saved on account of the mulberry trees.

149. *Annual Outturn.*—If three crops of 20 maunds each time, and five crops of 10 maunds each time, of seed-cocoons are reared every year, a total quantity of 110 maunds of cocoons will be obtained annually. If the *grainage* is worked on right methods, there will not be much doubt about a large

proportion of the crops being disposed of for seed. If seed-cocoons can be sold at Rs. 80 per maund, the total annual outturn may be as much as Rs. 8,800. If all the crops are not disposed of for seed, that is, if only 50 maunds are sold at Rs. 80 for seed and 60 maunds at Rs. 30 as reeling cocoons, the annual outturn may come to Rs. 5,800. If the whole of the 110 maunds have to be disposed of for reeling purposes at Rs. 20 per maund, the annual outturn may come to only Rs. 2,200. The actual outturn may be safely put down at Rs. 4,000.

150. *Profits from a Grainage.*—Doubts will naturally arise as to the possibility of the immense profits derivable from a *grainage*, according to the above statements. That in France and Italy, Dedier, Susani, and other *graineurs* following M. Pasteur's system of work, have become enormously wealthy, and that as a result of the working of their *grainages* the silk industry of Europe has revived completely within the last forty years, admit of no doubt, as these facts have come to be of historical importance. In this country, if properly organised *grainages* were to be established, men belonging to upper classes of society would have to engage in an agricultural pursuit, as the capital outlay required for the establishment of a *grainage* is beyond the means of the cultivator. But high-caste men have neither the inclination nor the aptitude for such pursuits. The physical labour required in carrying out any agricultural pursuit is so great that it is beyond the capacity of men belonging to higher classes in this country. No one in this country has been able as yet to establish a proper *grainage* by the outlay of a sufficient capital. In the silk districts of Bengal a number of well-to-do cocoon-rearers have started rearing seed. These men are making such large profits by adopting some of the important methods, such as using the microscope, disinfecting houses and appliances with sulphate of copper water and sulphur fumes, that they have now acquired the confidence of being able to start full-sized *grainages* properly equipped in the near future. The first cocoon-rearer of Bengal who has taken to seed-rearing on scientific

methods is Dandadhar Das of Kagachira (Malda). He has been carrying on the work for about seven years, and he has been able to secure a net average income of about Rs. 100 per month. Other cocoon-rearers, observing the continued prosperity of one of their fellow-castemen, have also learnt the work, and started seed-rearing on similar lines. These men also have found the business equally profitable. A capitalist wishing to lay out Rs. 2,000 or Rs. 3,000 in establishing a *grainage* should remember the following facts:—(1) The *grainage* ought to be established in a locality where there is little or no silk-rearing, but which is at the same time constantly frequented by cocoon-rearers. Rampur Boalia, Rajmahal, Tinpahar, Sainthia, Kandi, and a place near Rampur Hát Railway Station are the most suitable places for *grainages.* No seed-rearing has been commenced as yet in any of these places except Rampur Boalia. (2) Men who will be sent to learn the work should not be high-caste men (*i.e.*, Brahmans or Kayasthas), or men who have received high education, as engaging such men the capitalist will find the work mismanaged. High-caste men and men who have received high education acquire the habit of doing rough work only with great difficulty. Such men can seldom learn the work or carry it out in practice. The work is likely to be carried on properly if professional cocoon-rearers are got trained and employed to conduct the *grainage.* (3) The capitalist, though conducting the *grainage* through professional and trained cocoon-rearers, should himself be conversant with every detail of the work, and the *grainage* should be situated close to his dwelling place, that he may keep constant watch over the work. (4) The success or failure of the *grainage* will mainly depend on the trained men employed. They should therefore not only receive monthly wages, but also a share of the profits. Receiving only a monthly salary, they will be too apt to work like hirelings. That silkworm-rearing cannot be done by mere hirelings has been explained already.

PART III.

THE COMMERCIAL COCOONS.

CHAPTER I.

Various kinds of Silkworms.

151. *The Mulberry Silkworms.*—All varieties of silkworms fall under two classes; (1) Those which make reelable cocoons, and (2) those which make unreelable cocoons, *i.e.*, such cocoons as have to be carded and combed like cotton or wool before thread can be spun out of them. All varieties of domesticated mulberry silkworms and most varieties of wild silkworms that are found on the mulberry trees belong to the first of these two classes. The domesticated mulberry silkworms are : (1) the European silkworm or *Bombyx Mori*, (2) the *Barapalu* or *B. Textor*, (3) the *Nistári*, *Madrasi* or *Canary* silkworm (*B Craesi*), (4) the *Deshi* or *Chhotapalu* silkworm (*B. Fortunatus*), (5) *Cheenápalu* (*B. Sinensis*). Besides these there is a variety of silkworms called *B. Arracanensis* reared in Burma, and another variety called *Barapát* reared in Assam. These seem to belong to the *B. Textor* variety. The silkworms reared in Manipur are also *Barapalu* or *B. Textor*. Indeed, there is a tradition in Bengal that the *Barapalu* originally came from Manipur. In Midnapore there is a variety of silkworms called Bulu or Blue. These make small greenish white cocoons. These and the *Chhotapát* of Assam seem to belong to the *B. Sinensis* variety. Among wild mulberry cocoons, the *Theophilas* make good reelable cocoons. The *Ocinara*, *Trilocha* and *Randotia* varieties of wild mulberry silkworms spin very inferior cocoons. It is quite enough to mention their existence.

152. *The Tusser.*—Other silkworms also besides those that feed on the mulberry leaf produce serviceable cocoons. Of

these the reelable cocoons are—(1) *Bombyx Lasiocampa Otus*, (2) *Antheræ Yamamai*, (3) *Antheræa Pernyi*, (4) *Antheræa Assama* or *Muga*, (5) *Antheræa Roylli*, (6) *Antheræa Mylitta* or Tusser proper. All these cocoons may be classed under the generic name of Tusser. Other reelable cocoons have been also discovered, but they are so rarely found that it is impossible to establish an industry with their help. Wild mulberry cocoons and Tusser cocoons are found in abundance in certain localities of India. In such localities these cocoons are bought and sold and made use of.

153. *Inferior Cocoons.*—Cocoons that cannot be reeled are mostly useless. Of this class of cocoons, the Endi or Eri cocoons are the best. *Attacus Atlas* cocoons also fall under this group, and they also are spun by a class of silkworms which can be fed on castor-leaf. The *Attacus Atlas* cocoons contain almost ten times as much silk as mulberry cocoons or Eri cocoons. But this silk is not so soft as Eri or mulberry silk. The *Attacus Cynthia* is only the wild variety of the *Attacus Ricini*. The *Cricula* variety of silkworms are found in most parts of India in fairly abundant quantities. The fibre of this class of silkworms is made into thread by certain races of Chota Nagpur. There are hundreds of varieties of inferior silkworms the silk of which is not used, nor is there much probability of its ever being utilized. In France a variety of spiders spin cocoons in pear trees. The silk spun out of these spider cocoons has been also woven into cloth. But there is not much probability of the article ever being recognized in commerce.

154. *Lasiocampa Otus.*—Of all the varieties of cocoons mentioned above, the European mulberry cocoons are the best. A few years ago, a class of cocoons named *Lasiocampa Otus* was discovered in the kingdom of Dalmatia. Some sericulturists have expressed the opinion that this will be *the* cocoon of the future. These cocoons are large like Tusser cocoons, but the fibre is white and finer than mulberry silk fibre. The caterpillars making these cocoons feed on the variety of oak called *Quercus Ilex*. Whether this silkworm will ever be brought under domestication, or whether its silk will prove so

lasting and soft as mulberry silk, are matters on which no information has been obtained as yet.

155. *Theophila Cocoons.*—The *Theophila* cocoons of the Himalayas are almost as good as European mulberry cocoons. Probably all varieties of domesticated mulberry cocoons originally came from the *Theophila.* The class of domesticated mulberry cocoons which is reared in Thibet very much resembles the *Theophila.* In very ancient times the silkworms were probably taken from the Himalayan country to all other regions of the earth, where they underwent local differences in course of time. In the same country the same class of cocoons sometimes occur in great varieties, large and small, white and yellow. In warm countries the cocoons are loose; in cold countries they are firm. The loose and firm, small and large, all varieties of mulberry cocoons, seem to have originated from the *Theophila*, as the *Theophila* cocoons also are indifferently loose or firm, white or yellow. The appearance of the *Theophila* caterpillar and moth also resembles closely the appearance of the domesticated silkworm and moth (Figs. 16 and 17).

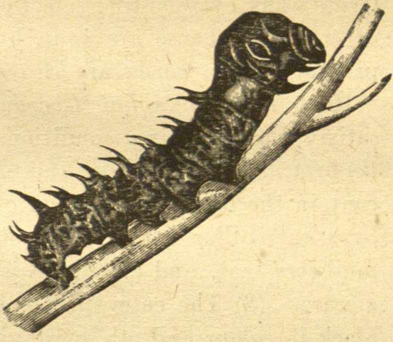


FIG. 16.—Theophila Silkworm.

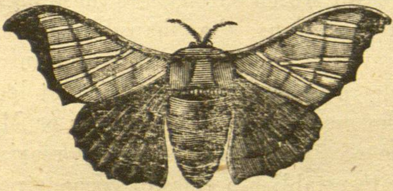


FIG. 17.—Moth of the Theophila Silkworm.

156. *Varieties of European Cocoons.*—European cocoons were nearly all derived originally from China. In China, sericulture advanced and spread at an older time than it did in any other country. In more recent times sericulture has made the greater progress in France and in Italy, and it is in these two countries that the best classes of cocoons are to be seen. The best Chinese cocoon is called *Pai-pi-tsan of Tien-tai.* This Pai-pi-tsan cocoon of China is the origin of the white Shanghai cocoon of Italy, which is recognized as the best of all. A class of cocoons, called in France *Moricauds* (Negroes) is spun by a black coloured and hardy silkworm. Other superior varieties of Italian and French cocoons are White Grand Sassoo, Yellow Grand Sassoo, White Abrussesse, Corso, Biyoni, Petit-Milanais, Gialla Montana, Novi Liguri, Erasmo Mari, Yellow Perugia, Fossombrone, Vallerogue, Blanc Bonsquier, Gros-Var, Yellow Cevennes, and Herault. Of the cocoons of other countries, the White Bagdad cocoons are the best. In size Persian, Bokhara, and Cyprus cocoons are the largest. At Bournabat, near Smyrna in Asia Minor, Mr. Griffitt has by scientific selection established a superior class of cocoons. These are spun by black and "Zebra" caterpillars. These worms are also very hardy.

157. *The Shanghai Cocoon.*—The best cocoon should satisfy the following conditions:—(1) It should be round, (2) firm, (3) silvery white, and (4) easily reelable. (5) It should contain the largest proportion of silk. (6) It should be spun by a caterpillar which does not consume a large quantity of mulberry leaf, and (7) which is not naturally subject to any disease. (8) The caterpillar spinning the cocoon should be black in colour and otherwise vigorous in appearance. There is no class of cocoons at present which satisfy all these eight conditions. Of these eight conditions, the Shanghai cocoon of Italy satisfies the first seven. The caterpillars spinning these cocoons are rather pale in colour, and they do not look vigorous. By combining the merits of the Moricauds or Mr. Griffitt's cocoons with those of Shanghai cocoons by rearing them together, it is possible to establish a class of cocoons possessing all the eight qualities mentioned above. This can be

done by selecting only black worms and round white cocoons for seed for eight or ten years successively. The classes of mulberry silkworms which spin very large-sized cocoons are particularly subject to grasserie and flacherie, and the proportion of silk on these cocoons is less, that is, the chrysalides are too large for the weight of silk on them. From 8 seers of green Shanghai cocoons of Italy one can get 1 seer of raw silk; while from 10 to 11 seers of green cocoons of the other superior varieties (such as Grand Sassoos, Bagdad cocoons, Mr. Griffit's cocoons, Fossombrones, Blancs Bonsquiers, White Abrussesse, etc.), a seer of raw silk is obtained. If only one class of European cocoons is reared, one should rear the round white Shanghai cocoons of Italy.

158. *European Cocoons in the Himalayas.*—In Kashmir, in the Punjab, and some other parts of India European silkworms have been reared quite successfully. From Kashmir to the northern parts of Assam, that is, throughout the Himalayan country, the mulberry tree is found in the wild state. The *Theophila* cocoons are also found abundantly in this region. The western part of the Himalayas is very much like France or Italy in climate. The eastern part is too wet for silk-rearing. Kashmir is the most suitable place for sericulture throughout all India. Wild mulberry cocoons are so common in Kashmir that the right to collect them is leased out annually by the State for about Rs. 2,000.

CHAPTER II.

THE BARAPALU.

159. *Neglect of the Barapalu.*—The *Barapalu* is the best of all varieties of cocoons raised in Bengal. The *Barapalu* cocoons of Murshidabad and Birbhum are beautifully white. The Midnapore *Barapalus* are indifferently white, yellow, salmon-coloured, and greenish white. The *Barapalu* is reared by very few people. There are two reasons for peasants neglecting such a superior class of cocoons:—(1) eggs of the *Chhotapalu*, the *Nistáripalu*, or the *Cheenapalu* take only

eight or ten days to hatch, but the eggs of the *Barapalu* hatch after ten months. (2) *Barapalu* eggs go on hatching for seven or eight days, or still longer, while the eggs of the other varieties of Bengal silkworms hatch completely in two or three days, when once the hatching does commence. If arrangements can be made for hatching *Barapalu* eggs in certain central establishments, and distributing hatched worms to villagers instead of eggs, the rearing of *Barapalu* can be made to assume some importance. Such an arrangement can be made in connection with *grainages*, where large quantities of *Barapalu* eggs can be conserved and hatched for distribution.

160. *Hatching of Eggs.*—The following measures require to be adopted for securing uniform hatching of the *Barapalu* seed:—

(1) The moths should be made to lay eggs on cloths.

(2) At least 15 days afterwards, or, if the eggs are microscopically selected, after this selection is over, the eggs that are to be stored are to be detached from the cloths by washing them in water. When eggs are rejected at the time of microscopic selection, little bits of cloth have to be cut away with scissors. It is only in the *grainages* that microscopically selected seed requires to be used. Very little cloth, therefore, will be wasted in this way. The cloth used for industrial seeding can be used over and over again after the eggs have been washed out of it. The method of washing out *Barapalu* seed resembles that employed for washing out European silkworm seed. This method will be described in Chapter III.

(3) The washed eggs are to be dried in the shade and put in porous and unglazed vessels made of sand and clay. Each of these vessels should contain only a small quantity of seed, say about 4 ounces. The eggs should not touch the bottom of the vessel, but a little loose cotton-wool should intervene. A couple of ounces of eggs should be put in a little linen bag. The mouths of the linen bags should be so tied or sewn together that the eggs may shake about freely inside the bags quite loosely. Two such bags should be placed

on a cushion of cotton-wool in each earthen vessel. There should be at least 6 inches of empty space between the bags of eggs and the cover of the earthen vessel. The cover is to be sealed on to the vessel with mud, and the vessel suspended in a cool room. The room in which the vessels of eggs are kept suspended should never be used for cooking in, that is fire should never be lighted in this room. This room should also be protected from currents of air and from the access of the rays of the sun. In January, that is at the coldest time of the year, the vessels of eggs should be kept in the coldest room. A room facing north but not draughty, and which is not used for cooking, or by too many people in sleeping, is well adapted for conserving seed. The vessels containing the eggs should be kept suspended from the roof, that is they should not be kept in contact with walls, lest white-ants and other vermin get access to the eggs and eat them up.

(4) In January or February, when it will be felt that the cold weather is departing, the sealed cover of the vessels containing the seed should be taken up, and the covers put lightly on the vessels, and they should be removed to a cook-room or some room which remains warm even at night. To keep eggs uniformly warm day and night, a simple device may be adopted. The linen bags containing the eggs may be taken out of the earthen vessels and kept suspended from the necks of persons by means of strings. A person carrying about a little bag of eggs inside his clothes will not be so very much inconvenienced, while the eggs will hatch properly. Another way in which uniform hatching of *Barapalu* eggs can be secured is to send them in a perforated wooden box to Kurseong, Kalimpong, or some other fairly cool hill station in the month of January, to have the eggs in this station only for 15 or 20 days, and then to bring them down again by post, and to keep the eggs in a uniformly warm temperature for 10 or 12 days afterwards. After this treatment the *Barapalu* eggs will be found to hatch all in two or three days. The secret of uniform hatching is to expose the eggs to rather severe cold for a period of a fortnight to two months, and then to keep them in a uniform temperature of about 75°F. for 10 to 12 days.

161. *The Barapalu out of Season.*—If *Barapalu* eggs are exposed to cold out of the proper season, and then kept in a warm place, they hatch at this improper season. It is possible to

take three or four crops of *Barapalus* during the same year, by thus subjecting the eggs to untimely cold. Both *Barapalu* and European silkworm eggs can be hatched at any time of the year by another simple method. Newly-laid *Barapalu* or European silkworm eggs being dipped in strong hydrochloric acid, kept in it for 5 minutes, and washed with water immediately afterwards and dried, hatch in 10 or 12 days like *Nistári* or *Chhotapalu* eggs, provided they are kept in a warm place during those days. If the moths are made to lay eggs on cloth, then the cloth should be dipped in hydrochloric acid within 10 or 12 hours after the eggs have been laid. After 5 minutes the cloth should be taken out of the acid and washed in water. Water should be changed eight or ten times; and the eggs washed every time by dipping the cloth in it. The water should be made to run out after each washing in such a manner that detached eggs may not run out with the water. In washing the cloth eight or ten times, a great many eggs will get detached in the water. But good eggs sink in water, and there is little risk of losing eggs if one allows the supernatant water to drain out gently after each washing. At the last washing, the vessel containing the water may be upset on the cloth of eggs or on a sheet of blotting paper, and the water allowed to strain out of it. In this way all the eggs will again be collected on the cloth. These should be spread out thin on the cloth, and got dried immediately afterwards by keeping it exposed in an open but shady place. Eggs should never be dried in the sun. In a *grainage* all the eggs used, whether they are in time or out of time, should be microscopically selected. The worms, when they have hatched out of the eggs, are reared exactly as *Nistári* or *Chhotapalu* worms are reared. When the cocoons have been formed, the whitest and the best should be reserved for seeding. All the seed-cocoons should be strung up with thread. The moths that are to be subjected to microscopic examination are to be covered up separately on the cloth with little earthen cups. The moths that are to be seeded industrially should be weighed, and certain definite quantities then put on pieces of paper or cloth. The male moths should be picked out of these after some hours, and the female only left to lay eggs. The eggs that are to be made to hatch artificially with the help of hydrochloric acid are to be kept separate, the worms from them being reared and used again for getting more seed from. Practically only a small quantity of eggs can be made to hatch artificially, as hydrochloric acid is not a cheap substance. But it can be regularly used in the *grainage*. Three hundred *Barapalu* moths can be examined in four hours, and thus 2 ounces of eggs can be selected out. If these are treated with hydrochloric acid immediately afterwards for 5 minutes and washed, the eggs will produce at least 1 maund of cocoons. From 1 maund of cocoons about 4 seers (128 ounces) of eggs are obtained. If an ounce of eggs is sold for Rs. 2, seed worth Rs. 250 can be raised out of due time by adopting this artificial method. To spend an extra rupee in buying strong hydrochloric acid is no loss when the result to be achieved is so large. Naturally, the eggs of the *Barapalu* hatch in January, and the cocoons are obtained in February. A couple of ounces of seed from these cocoons may be made to hatch in March by treating them with hydrochloric acid. The second crop of cocoons will be obtained in April; and in any locality where March and April are fairly cool (70° to 80°F.), a crop of *Barapalus* can be taken during these months. From the middle of April to the middle of June, where heat is intense, no rearing of *Barapalu* silkworms should be done. A couple of ounces of eggs from the first *Barapalu* crop may be sent up in July (after the commencement of rain) in a perforated wooden box to Darjeeling, or some other hill station. The eggs should be kept in this cool place for two months, and brought down to the plains of Bengal, or some other warm place, in August. The eggs will hatch in seven or eight days after their arrival, and a third crop of *Barapalu* cocoons will be obtained early in September. The newly-laid eggs from these cocoons may be treated with hydrochloric acid, and a fourth crop may be obtained in October. From October to January, the weather being suitable for rearing *Barapalus*, four crops may be taken in succession during the four months by hatching the eggs in an artificial manner. To get eggs to hatch four times during the four months is not impossible. Two ounces of eggs from the first, that is the February crop, may be sent to a hill station at the end of July, kept there until the end of September, brought down to the plains, where they will hatch early in October, and a fifth crop of *Barapalu* cocoons will be obtained at the end of October. Out of the fourth crop, obtained early in October, a seer of cocoons may be seeded, the eggs selected treated with hydrochloric acid, and got to hatch early in November, the sixth crop of *Barapalu* cocoons being obtained at the end of November. From the fifth crop, obtained at the end of October, a *chitak* (2 ounces) of eggs may be obtained, treated with hydrochloric acid, and made to hatch early in December, the seventh crop of *Barapalu* being obtained at the end of December. A third *chitak* of eggs from the first or the February crop may be sent up to a hill station in October, brought down in December, and the eggs got to hatch at the end of December. An eighth crop of *Barapalu* cocoons may be thus obtained in January.

162. *Artificial Hibernation.*—(1) It has been said that the rearing of *Barapalus* should not be done from the middle of April to the middle of June on account of excessive heat being prevalent at the time, this heat being injurious to eggs sent by post. (2) It may also be inconvenient to arrange for the conservation of seed in a hill station and for the despatch of it from time to time to the plains. (3) In some hill stations it is so very wet from June to October that there is great risk of the eggs getting damp if they are stored in such a station. It is very important to have the eggs in a dry condition throughout the year. It is possible to keep the eggs in a dry condition even in a very damp place by using quicklime. But it may be inconvenient to arrange about this in a hill station. For the above three reasons artificial hibernation in a refrigerator may be found more convenient in certain localities. In many mufassal town ice is sold in the hot weather. If arrangements for selling ice can be made in connection with a *grainage*, and if the ice is kept in a specially constructed box, hibernation of eggs can take place at will. It is too expensive to get up ice daily from Calcutta only for hibernating eggs. A *grainage* situated in a mufassal town can easily utilize the ice brought up for hibernating seed by selling it, and thus bringing an

extra profit to the seed-rearer. Fig. 18 represents a box which can be used for hibernating eggs, also for storing ice. A box 3 feet in length, 3 feet in width, and 3 feet in height should be procured, and another 2 feet in length, 2 feet in width and 2 feet in height. Both the boxes should have lids. The boxes and lids should be lined inside and outside with sheets of zinc. Ice should be put in the larger box, the smaller box put on this ice, and after putting the lid on the smaller box more ice is to be put on, and the lid of the larger box is to be placed finally in position. The boxes are to be placed on a heap of dry sawdust or ashes, and this material should also be heaped round it. There should be a pipe at the bottom of the larger box to let out the water from inside it twice a day. There

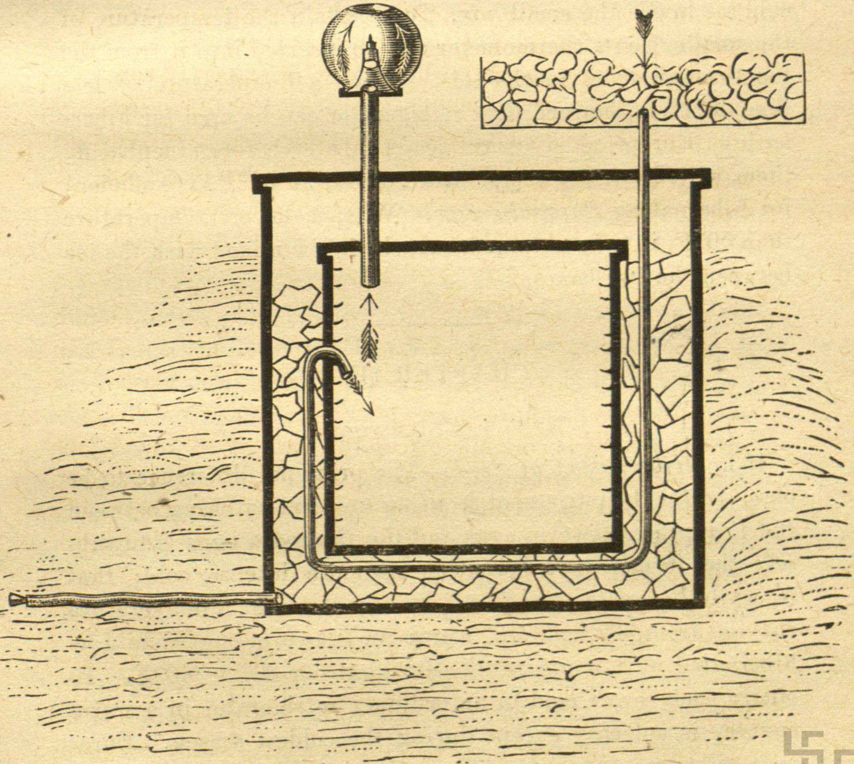


FIG. 18.—The Refrigerator.

should be two other pipes, one admitting fresh air inside the smaller box, and the other carrying away impure air from it. When eggs are hibernated inside the smaller box, it should be seen that the air which enters it should be thoroughly dry. The two ventilation pipes should stand erect above the lid of the outer box. One should end in a box of quicklime, and the other in a lamp with a globe round it. In this way pure air will be continually drawn in in a dry state through the mass of quicklime. This air, passing through a lead pipe which goes round three sides of the smaller box through masses of ice, will enter the small box not only dry, but also cold. The lamp in the middle of the globe will continually draw in air from below, which will cause a constant circulation of dry and cold air inside the small box. To ascertain the temperature of the smaller box a thermometer can be inserted into it from the top through holes in the lids. When a temperature of less than 40°F. is obtained, this refrigerator can be used for hibernating European silkworm eggs also, before incubating them with heat. A temperature of 50° to 60°F. is sufficient for hibernating *Barapalu* eggs. When a lower temperature than 50°F. is to be obtained, salt should be mixed with the ice between the two boxes.

CHAPTER III.

EUROPEAN SILKWORMS.

163. *Hibernation of Seed.*—The principal difference to be observed for the purpose of securing uniform hatching between the European silkworm eggs and the *Barapalu* eggs is to subject the former to hibernation in more intense cold; that is, while *Barapalu* eggs should be hibernated at a temperature varying from 50° to 60°F., European silkworm eggs should be hibernated at a temperature varying from 30° to 40°F. To obtain such severe cold in an ordinary refrigerator in a warm country is not easy except during the coldest season. European silkworm eggs sent to Darjeeling or some other cold hill station in December, and brought down to the plains two

months afterwards, hatch in 10 or 12 days, if they are kept in a uniformly warm place during these 10 or 12 days. To make arrangements for getting such intense cold at other seasons is possible only in large towns like Calcutta, where chemicals and machinery are used for freezing water even in the hottest weather for obtaining ice. Arrangements may be made for securing a small chamber with a temperature of 30° to 40°F. in an ice factory, where European silkworm eggs can be hibernated at all seasons of the year. Professor Duclaux of Paris has ascertained, by carefully conducted experiments, the length of time eggs require to be kept in a warm place before they are subjected to a temperature of 30° or 40°F., and the duration of the hibernal period, before satisfactory hatching is obtained. The result of Professor Duclaux's researches is, one is now able to hatch European silkworm eggs at all times of the year, if one can strictly follow the arrangements he prescribes.

164. *Drawbacks to rearing the European Silkworms.*—There are certain drawbacks in rearing European silkworms in Bengal. (1) They usually die of flacherie if they are reared from April to August. (2) They do not, as a rule, make good cocoons fed on the ordinary shrub-mulberry of Bengal. They require to be fed on leaves gathered from trees, or mature but fresh leaf of the Bengal mulberry. Where large trees are available, it is more profitable to rear European cocoons than Bengal cocoons. The *Chhotapalu* variety of silkworms do not make good cocoons on leaf gathered from large trees, and if the leaf happens to be mature, *Chhotapalus* take flacherie. European silkworms, *Barapalus*, and *Nistáris* spin good cocoons fed on leaves gathered from all kinds of mulberry trees except the *Morus Nigra.* If one does not care to have Bengal mulberry at all, but would depend entirely on trees, one should not rear the *Chhotapalu* at all, but go in for rearing chiefly the European silkworms. European silkworms spin superior cocoons which contain more silk than the other varieties of mulberry cocoons. It is only in fineness that the Bengal silk fibre excels other silk fibres; but this fineness is of no avail.

Where five or six Bengal cocoons would be reeled off together, three or four European cocoons would be used for obtaining the same thickness or "size." No class of cocoons, whether European or Indian, is reeled off singly. In Part IV, Chapter VI, will be found a table which gives the length of fibre, the fineness, the strength and the elasticity of the European, the *Barapalu*, the *Nistári* and the *Chhotapalu* silks. The superiority of the European silk will be apparent from this table.

165. *European Silkworms out of Season.*—As by subjecting *Barapalu* eggs to cold out of the proper season, or dipping them in strong hydrochloric acid, three, four, or more crops of *Barapalu* cocoons can be reared during the year, European silkworm eggs can be similarly reared by untimely hibernation, or by treating newly-laid eggs with strong hydrochloric acid, washing them 5 minutes afterwards with water, drying them immediately afterwards, and keeping them for about 12 days in a uniform temperature of 75° F. In a *grainage* a few ounces of European silkworm eggs can be microscopically selected, artificially hatched with hydrochloric acid, and three or four seed crops taken in one year. All these different lots of seed can be sent up in the cold weather to a hill station and brought down after a month or two, when they will all be found hatching at the same time, that is within 10 to 15 days after they are brought down from the mountain. This rule applies to the *Barapalu* eggs also. Both *Barapalu* and European silkworm eggs should be kept in a warm place for at least two months after they are laid, before they are sent up for hibernation to a mountain or put inside a refrigerator. If newly-laid eggs are hibernated and then incubated in a warm place, they do not hatch. *Barapalu* and European silkworm eggs thus require to be in three conditions successively before they hatch. The eggs of the *Nistári*, the *Deshi* and the *Cheenápalu* do not require to be placed in these three conditions, *viz.*, a period of warmth followed by a hibernal period and then by a period of uniform warmth of 75° F., but they hatch evenly at all times of the year in the climate of Lower Bengal without any trouble. In fact, one of the principal causes of the neglect of the *Barapalu* and European silkworms, notwithstanding their producing superior cocoons, is the ease with which the ordinary Bengal varieties of silkworms

can be reared. It will be extremely difficult ever to popularize the rearing of the superior varieties of cocoons among the peasantry of Bengal. If exact methods of conservation and also of hibernation and of incubation are adopted in a well organized *grainage*, there is some hope of cultivators buying hatched-out worms from such a *grainage*. *Barapalu* and European silkworms, when they have once hatched out from eggs, are reared exactly in the same manner as *Chhotapalu* or *Nistári* worms. Only in rearing European silkworms it should be remembered that they prefer mature leaf or leaf gathered from large mulberry trees.

166. *Incubation.*—It is not easy keeping the eggs at the temperature of 75° F. night and day for 10 to 12 days after they have been hibernated. It is possible to do it in Lower Bengal in the cold weather, *i.e.*, from November to February, if eggs are kept spread out on a *dálá* placed on a *máchán* erected in a small room fitted with glass doors and windows, and if a couple of lamps with chimneys and globes and two or three thermometers are kept ready. Whenever the thermometer placed close to the eggs indicates a lower temperature than 75°F., (1) the lamps may be brought closer to the *máchán*, or (2) the *dálá* containing the eggs may be placed higher up in the *máchán*, or (3) trimming the lamps so that they may burn brighter, until the temperature of 75° F. is restored. In some places the winter is so severe that a temperature of 75° F. cannot be secured simply by having one or two lamps burning in a small room. In such a case it is necessary to warm up the room with fire. If the thermometer near the eggs indicates a higher temperature than 75° F., (1) the *dálá* on which the eggs are placed should be removed to a lower place in the *máchán*, or (2) one of the lamps blown out, or (3) both of them lowered, or (4) one of the windows opened out, until the temperature of 75° F. is restored. In the hot season in Bengal when the temperature is naturally a good deal above 75° F., it is impossible to make proper arrangements for incubation except in an ice factory. It does not do much harm if eggs hatch when the temperature is as high as 80°F. But when incubation takes place at a still higher temperature, worms from European seed become liable to flacherie. It is not to be supposed that European seed does not hatch at all, or if it hatches

that the worms must perish through flacherie if the exact method of incubating the seed is not followed. Hibernated seed kept in a warm place afterwards hatch more or less satisfactorily; only the hatching goes on for a long time. Hibernated seed kept in a uniform temperature of 75° F., until hatching takes place, finish hatching in three or four days. In some villages in Europe a simple practice still prevails which enables silk-rearers to keep their seed in uniform temperature with very little trouble. Their women keep the little bags or boxes of seed suspended from their necks with pieces of string, keeping them inside their clothes and in contact with their body. Eggs hatch fairly well incubated in this way. An incubating machine is also used for hatching European silkworm eggs. It is simply a box with a double compartment. In the lower compartment a lamp is kept lighted, and above it a vessel of water. In the upper compartment the boxes of eggs are kept arranged, and a thermometer placed alongside the boxes (Fig 19). For *grainages* in this country also an incubator of this sort may come to be used with the introduction of European cocoons or the revival in the rearing of the *Barapalu*.

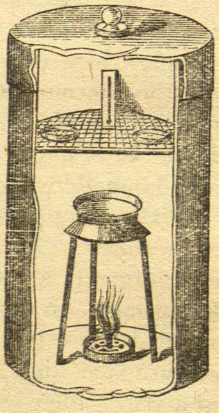


Fig. 19.—The Incubator.

167. *Washing of Eggs.*—It does not hurt *Barapalu* or European silkworm eggs if they are left on the paper or cloth on which they are laid, and hibernated and incubated in this condition. The object of washing the eggs loose is to keep them stored within a smaller compass. But there is one disadvantage in having them in a loose state. Chopped-up leaf, spread on loose eggs when they are hatching, though it enables the newly-hatched worms to crawl on to the top, gets entangled with the loose eggs when the leaf is transferred with the worms to a *dálá*. These eggs hatching a day or two afterwards, worms of different sizes remain mixed up in the same *dálá*. There is a remedy against it: a piece of mosquito curtain net may be spread over the loose eggs, and leaf sprinkled over the net. The interposition of the net enables only the hatched worms to get through and eat the mulberry. When the leaf with the worms is removed to a *dálá*, eggs do not get mixed up with the leaf. When eggs remain attached to paper or cloth by means of their natural gum, they do not require a net to be spread over them before leaf is put on them. But eggs of all varieties of silkworms, whether of *Barapalu* or of European silkworms or of *Nistári* or *Deshi* silkworms, should be washed with sulphate of copper water some time before hatching takes place. If one does not wish to have the eggs detached from the paper or cloth on which they are laid, the paper or cloth should simply be dipped in the sulphate of copper bath, and immediately taken out and exposed in a shady place to get dry. If eggs are laid on *dálás*, it is not convenient washing them in sulphate of copper or keeping them stored for ten months. *Dálás* when wet do not dry up so quickly as sheets of paper or of calico do. If eggs remain wet with sulphate of copper water for 4 or 5 hours together, some of them are killed by the corrosive action of the sulphate of copper. Even when the eggs are deposited on paper or calico, it should be seen, after the sulphate of copper dip, that the water does not remain accumulated at any particular spot, forming distinct blue deposits. If it does, the paper or calico should be dipped in plain water to remove this excess

of the copper solution. If one is doubtful as to which sheets of eggs require the dip in plain water also, one can dip them all in plain water, after they have remained wet with the sulphate of copper water for 5 minutes. The full benefit from the copper solution is obtained if sheets of eggs remain moist with it for 5 minutes only. If the sheets of eggs are dipped in copper solution and taken up immediately afterwards, and then after 5 minutes if they are dipped again in plain water and taken up immediately afterwards, very few eggs will be found getting detached in the water. If for convenience of storing the seed, it is considered desirable to get the eggs detached from the cloth on which they are laid, a brush should be used when the cloth is put in plain water (5 minutes after the sulphate of copper dip) in detaching all the eggs and collecting them in the water. If it is found that the eggs do not get brushed out easily, a little methylated spirit (1 part of spirit to 100 parts of water) should be used to dissolve the gum of the eggs completely. When all the eggs have been brushed down from the cloth into the water, the vessel containing the water and the detached eggs is to be turned upside down on a piece of calico, and the eggs being gathered on it are to be spread out thin and dried in shade. Although the washing in sulphate of copper, or the detaching of eggs from the cloth on which they are laid, can be done any time before hatching, yet the most suitable time for doing this is the pre-hibernal period. If for any reason it becomes necessary to wash the eggs at the hibernating or the incubating period, then the temperature of the water used for washing the seed should correspond exactly with the hibernating or the incubating temperature, as the case may be, and a thermometer should be used that this temperature may be exactly secured. Washing of the European and *Barapalu* silkworm eggs should not be done within ten days after they are laid, nor within ten days before hatching takes place. At these two periods eggs require to breathe pretty freely. If, therefore, eggs are left submerged in water during these two periods for any length of time, they may get asphyxiated and killed. If hydrochloric acid is used, eggs require to be washed in water within 10 or 12 hours after they are laid; but this washing should be done very quickly, that eggs may not suffer from asphyxiation. *Chhotapalu* and *Nistári* eggs may be washed in sulphate of copper solution any day before hatching takes place. As eggs of these varieties of silkworms do not require to be detached from cloths and stored for a long time they need not be kept inside the bath for more than a second.

168. *Spinning of Cocoons.*—When *Chhotapalus*, *Nistáripalus* or *Barapalus* ripen, they can be easily distinguished, picked out from *dálás*, and placed on *chandrakies* to make cocoons. European silkworms cannot be so readily distinguished when they are ripe, and they do not settle down quietly on *chandrakies* to make cocoons when they are picked out and put on the *chandrakies*. They have the tendency of congregating at the top part of the *chandrakies*, and when they get the chance they crawl up the wall on to the roof of the house, and there make cocoons in the straw thatch. Special arrangements are required for European silkworms making cocoons. After the worms have gone through the fourth moult, dry branches of spruce or *arahar* should be tied in bunches at regular intervals on the posts and cross-pieces of the *mácháns*. When the worms ripen, they naturally get vagabond, and in moving out of the *dálás* and coming in contact with the dry branches in the posts or cross-pieces of the *máchâns*, they get inside these branches and make cocoons. Worms that crawl out of the *dálás*, even after fresh leaf is put on them, are ripe worms for certain. These can be separately picked out and placed at the bottom part of a *chandraki*, in which case they crawl up and make cocoons in the *chandrakies*. If dry twigs are not tied at regular intervals on the *máchâns*, most of the healthy worms when ripe will crawl out of the *máchâns* altogether, and get devoured by rats or destroyed by ants. European silkworms, affected with flacherie, do not evince such a vagrant tendency. When this is the case a great many cocoons are found spun in the litter. Bengal cocoons spun in the litter can be safely used for seed,

as they are comparatively stronger, but European cocoons spun in the litter should never be used for seed. Cocoons spun by vagrant European worms yield the best seed.

CHAPTER IV.

Rearing of Tusser Silkworms.

169. *Yamamai Tusser.*—Of all the *Antherœa* or tusser cocoons of commerce, the *Yamamai* cocoon of Japan is the best. The *Antherœa Yamamai* has been also discovered in the Himalayas. The fibre of the *Yamamai* silk is almost as white and shining as that of the mulberry silk. The law of Japan visits with capital punishment any one exporting the seed of this variety of tusser. Under such circumstances there will be an initial difficulty in introducing the rearing of this variety of silkworms in India. If seed of the *Yamamai* tusser can be secured, the caterpillars can be reared exactly in the same way as the ordinary tusser caterpillars of Bengal. The trees, the leaves of which form the staple food of the *Yamamai* caterpillar, are to be seen in the Himalayas at an elevation of 3,000 to 4,000 feet above the level of the sea. In Nepal and Sikkim these trees are variously known as *Sabluth*, *Buk*, or *Bajrath*. It is a variety of oak (*Quercus Serrata*). Its timber is excellent. If the planting of this tree and the rearing of the *Yamamai* silkworm can be regularly carried on in the Himalayas, that tract of country will be greatly benefited. It has been mentioned in Chapter I that throughout the Himalayas an excellent variety of mulberry, the *Morus Serrata*, and a superior kind of wild mulberry cocoons, called *Theophila*, abound. This tract of country should be recognized as the tract most naturally suited for rearing both the domesticated and wild silkworms.

170. *Roylli Tusser.*—The variety of tusser called *Antherœa Roylli* is also sometimes seen in the Himalayas. The silk of this variety of tusser also is whiter and more shining than the ordinary tusser silk of Bengal. The caterpillars of this variety of tusser make cocoons on the Himalayan oak and walnut trees after eating their leaves. The fruits and timber

of the walnut tree are both valuable. The propagation of these trees and the systematic rearing of the *Antherœa Roylli* are also likely to benefit the Himalayan country.

171. *The China Tusser.*—The tusser silkworm of China is called *Antherœa Pernyi.* The silk of this tusser also is whiter and softer than the ordinary tusser silk of Bengal. It may benefit the tusser-rearing industry of Bengal if the seed of the China tusser can be introduced into Bengal with the object of supplanting the staple silk product of Sonthalistan by a superior article. But the Bengal tusser has one advantage over the China tusser. The Bengal tusser cocoon has more silk. The China tusser silkworm has one more advantage over the Bengal tusser worm. The former is not so wild in character. It is impossible rearing the Bengal tusser silkworms indoors on *dálás,* but the China tusser worms can be reared either on trees or indoors on *dálás.* The tusser caterpillars in China feed on the oak leaf, and they are reared in much cooler places than the Bengal tusser caterpillars are. So it is doubtful whether the China tusser worm can be successfully introduced in Sonthalistan. Quite recently the Inspector-General of Forests has been interesting himself in the introduction of the China tusser silkworm into Indian forests. The following document will be of interest to those who may wish to repeat the experiment, as it gives some practical hints regarding the rearing of the insect:—

"Dated Yinohiapu, the 9th November 1897.

"*From*—OTTO ANZ, ESQ.,

"*To—Her Britannic Majesty's Consul, Newchwang.*

"AGREEABLY to your request, I am sending by horse-cart the following packages to your office:—

(1) One box, wrapped in hemp cloth, gross 85½ lb., containing net 18 lb. of acorns as per details given in my private letter of 6th instant. The majority of the acorns is of *Quercus Robur;* but in the one tin about 2½ lb. will be found at the bottom of the tin kept apart by a piece of matting of the large-leafed oak.

(2) One larger box perforated on four sides, gross 96½ lb., containing 3,500 live *Pernyi* cocoons, weighing net 45 lb.

(3) One tin, wrapped in paper, addressed English Consulate, Newchwang, containing samples of leaves and branch tops of *Quercus Robur* and *Quercus Dentata* (*viz.* the large-leafed oak), collected rather out of season, as owing to my absence in the interior your request reached me only a few days ago.

" Still these specimens will assist Mr. Ribbentrop in finding out what kinds of leaves are really used in this part of China for the cultivation of oak silkworms, and what the nature of the foliage is here, besides three envelopes on which some details of their contents are given. I have packed into this---

No. 1. *Quercus Robur.*
,, 2. Ditto.
,, 3. *Quercus Dentata*, some more leaves.
,, 4. Ditto, top pieces of branches.
,, 5. One top piece of a *Quercus Dentata* branch with what I consider to be a parasite. This very frequently occurs with low bushes of the large-leafed oak here, while I never saw it on the larger trees on the same kind of oak, nor on the bushes or trees either of *Quercus Robur*.

" With regard to the live cocoons, I beg to enclose a special direction for the treatment of this box on board the steamer from Hong-Kong, so as to secure safe delivery at Calcutta of the chrysalyses in their cocoons, *i.e.*, to prevent their coming out of the cocoon as a butterfly, as well as their suffocation through want of air. I should recommend that the packages be sent on from Hong-Kong by some direct steamer to Calcutta, provided the same have a cold store-room in which the two cases might be put; probably one of the Apcar Line steamers would be suitable. I am afraid that were the boxes entrusted to the care of a Chief Steward on board of a mail steamer, sufficient attention might not be given by the Stewards of the connecting steamer at Colombo, unless Her Majesty's Consul at the latter place would look after it.

"As I explained verbally to you, *Pernyi seed* cannot be shipped in the state of eggs, as these come out (into worms) after 15—20 days, and could not safely be obtained now, the development of the chrysalyses requiring from five to seven months under the natural conditions of this kind of silk tusser, which is quite different, in this and other respects, from the mulberry-fed worm. I could not help, therefore, to deviate from the tenor of Mr. Ribbentrop's order.

"With regard to the explanations contained in the letter, I further venture to remark that it would be a pity in my opinion to abandon the native tusser silk of India, as my studies of these have shown that they possess qualities specially adapting them for important requirements of the silk industry; I hope to be able to prove this in the course of next year.

"But while recommending to further, nay, to greatly increase, the culture of Indian tusser (*Antheræa mylitta*) on an improved basis I am inclined strongly to support Mr. Wardle's suggestions to introduce into India the culture of *Antheræa Pernyi* too. The silk of the latter has other properties which for other requirements give a value superior to that of *Antheræa mylitta*, and from a point of view, considering the economic value of both kinds for India, as a whole, I should think that it would be wise to neglect it now; or, as the one of two silks, the *oak* silk is not indigenous in India, to import its culture to the benefit of the cool and hilly regions, while the culture of tusser *mylitta* would, if based on better principles, largely benefit the poorer classes of the people in the tropic parts of India.

"Another remark of Mr. Ribbentrop's letter causes me to express confidence that it will not be necessary to import any new kinds of oak into India. I suppose *Quercus Robur* will be found in the Lower Himalayas, and specially in Kashmir; but *any* kind of the earlier oak varieties ('*Sounner-eishen*') would do in my opinion, as these worms are not very particular with regard to their food, which is amply proved by the fact that even the leaf of the 'widter-eishen,' which I suppose the large-leafed oak to be, is readily taken by the same breed, and in dry seasons even preferred as the more juicy one, although the cocoons made by worms fed on this kind of oak *Quercus Dentata* give a darker silk than that of worms fed on *Quercus Robur*. The latter would be the most suitable oak for this silk culture, together with *Quercus Castaneœfolia*, this being the staple food in Shantung for *Antherœa Pernyi*.

"Everywhere in China the rearing of these worms is being carried on in the open (except for the first and often for the *two* first stages of the spring worms), and on low bushes scarcely ever more than from 5 to 8 feet high, *viz.*, on what we call in Germany 'Eichenkratt' or plantations, in my opinion *naturally* formed, and having existed probably for centuries on the countless hills of Northern China, especially in Shantung and Manchuria. Should such 'Eichenkratt' be found on the southern slope of the Himalayas, it would of course be *the* best region where to instal this culture, but it would not be a condition *sine quâ non* as I know (by trials made in Germany and controlled by me at the request of the Prussian Government) that middle-sized trees as used for the 'Eishenchâlwald rteriet' give splendid foliage for rearing these cocoons, and can easily stand being bereaved of one-fourth and more of their foliage without in any way injuring the development of the tree. This would seem to be important when Mr. Ribbentrop thinks of trying the leaves of oaks *native* in the Indian forests, and of using the cocoons now going to India for such trials already. It would then come to rearing the worms not in the open but under sheds, which with very little cost could be erected in or near the forests where such oaks are found. The Japanese do the same very often with their 'Yamama' cocoons (*vide* 'Baviar Japans Seiden-sutht'). I have seen it in Germany too, and I am personally of opinion that the results would be so much safer, giving so considerably larger quantities and such a good percentage of the healthiest cocoons, that the expenditure would more than be covered by the higher value of the crops so received. In respect to this I may mention that the leaves ought to be cut, with short branches, and the latter put into earthen pots or wooden boxes filled with wet sand, and that when the branches are to be changed, the fresh ones must be put near to the used ones *in the direction from which the light comes.* The worms will then soon give up the older branch for the fresh one.

" Mr. Ribbentrop will be sure to know that the acorns must be planted with the least possible delay. The Chinese allow the young plants to grow for five years, then they are cutting them near the root, so that a largest possible number of twigs is springing up which are giving leaf best suited for feeding the worms. Of course bushes used for one generation of worms must never be used again unless after having grown freely for at least one shoot ('trict').

" I hope the above details will be sufficient to do away with any doubts, and that I will be excused for having carried owls to Athens, perhaps in my strong interest for the whole of this question. Should anything be wanting, I am of course most willing to supply further information.

" Finally, I beg to enclose account of the expenses incurred for the carrying out of your order, amounting to 10 dollars 70 cents, which please refund to our Newchwang office."

172. *The Muga Tusser.*—The Muga silkworm (*Antheræa Assama*) is reared in Assam. The silk of this variety of tusser is also whiter and glossier than the Bengal tusser silk. The eggs are made to hatch indoors, but the worms are reared on trees. When the worms are ready to make cocoons, they are again brought indoors, where they spin cocoons. The Muga silkworm feeds on the leaves of the Assam Champaka tree (*Michilia* sp.), the Sum tree (*Machilus odoratissima*), the Sualu tree (*Tetranthera monopetala*), the Mijankuri tree (*Tranthera polyantha*), and a few others. They produce cocoons five times in the year. In the cold weather and in the rainy season, it being inconvenient to watch the caterpillers on trees, they are reared chiefly in spring and autumn. At other seasons a few persons rear some simply to keep up seed.

173. The *Bengal Tusser*.—The main outward difference observable between the Bengal tusser cocoon and the four varieties of tusser cocoons above alluded to consist in the former possessing a peduncle (see Figs. 20, 21, and 22). The Himalayan tusser, called the *Antherœa Frithi*, also possesses a peduncle. There is, indeed, very little difference between the *Antherœa Frithi* and the *Antherœa Mylitta* of Bengal, which cannot be accounted for merely by climatic differences (Fig. 23). By means of this peduncle the cocoons are firmly attached to the branches of trees. After the peduncles are cut away, the Bengal tusser cocoons are reeled in the same way as other tusser cocoons. The difference there is in the whiteness and softness of the different varieties of tusser silk has been already noticed.

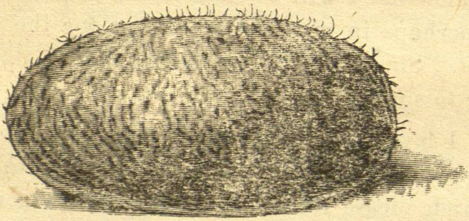


FIG. 20.—Antherœa Yamamai Cocoon.

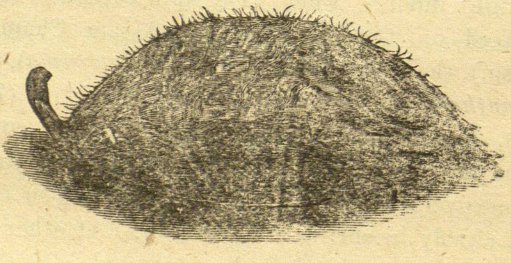


FIG. 21.—Antherœa Pernyi Cocoon.

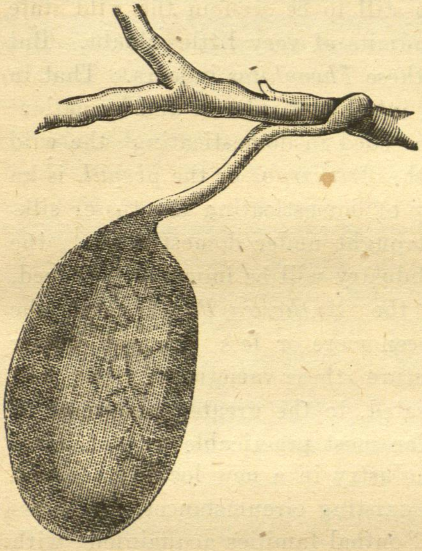


FIG. 22.—Antheræa Mylitta Cocoon.

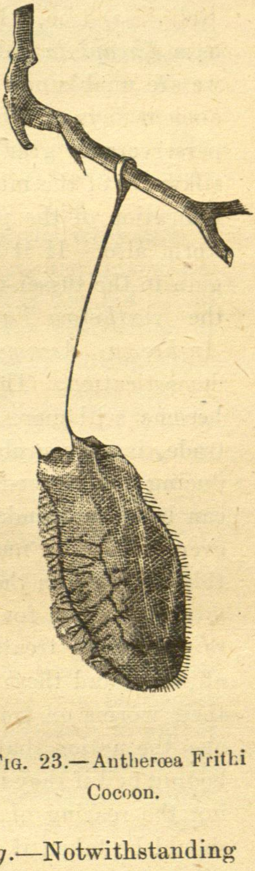


FIG. 23.—Antheræa Frithi Cocoon.

174. *General Principles of Rearing.*—Notwithstanding the difference in the quality of silks from different kinds of tusser cocoons, the same method may be adopted in rearing the caterpillars of all kinds of tusser. The Sonthals of Bengal have reared the tusser cocoon for ages, and no better method of rearing this cocoon has yet been devised than that which prevails among the Sonthals. Some European gentlemen have attempted to rear the tusser silkworm altogether indoors, but no one has yet achieved much success. That the mulberry silkworm was at one time brought under domestication, being originally obtained from the wild mulberry tree,

the *mádár* tree (*Artocarpus lacoocha*) or the *peepul* (Ficus Religiosa) tree, where it is still to be seen in the wild state as a *Theophila* silkworm, admits of very little doubt. But we are unable now to rear these *Theophilas* indoors. That in ancient days men by taking intelligent interest and by patient perserverance gradually succeeded in domesticating the wild silkworm of the mulberry, the *Artocarpus* or the *peepul*, is an indication of the possibility of domesticating the tusser silkworm also. If it can be brought under domestication, the gain to the tusser-rearing industry will be immense. Indeed, the *Antherœa Yamamai*, the *Antherœa Pernyi*, and the *Antherœa Assama* have been more or less brought under domestication. That in future these varieties of tusser will become still more domesticated, to the greater advantage of trade, is very probable. The most practicable way of introducing the tusser-rearing industry in a new locality, which can be recommended under existing circumstances, is however, to settle a number of Sonthal families acquainted with this industry in the new locality. The Sonthals have a hereditary affection for the tusser caterpillar, and certain notions regarding its treatment acquired from their childhood. This affection and these notions enable them to watch patiently their worms on trees all day and at all seasons. They have also the notion that they are liable to supernatural visitations boding evil if they neglect any of their traditional rules regarding the rearing of tusser silkworms. Another precaution should be taken if it is intended to newly introduce tusser silk-rearing into a forest country. The tusser worms ordinarily reared by Sonthals and others are naturally feeble. They take three, four or five broods in succession of these feeble worms, and then resort to the wild and hardy stock for seed purpose. Wild tusser cocoons are found in almost every jungle in India. Men and women cutting wood in jungles in Birbhum, Manbhum, Singhbhum, and the Sonthal Parganas, also collect wild tusser cocoons when they get any, and bring them to *háts*, villages, and towns for sale. The Sonthals prize these wild cocoons so highly that they buy them at four or five times the price of ordinary tusser cocoons. If such wild cocoons are not easily discovered in a jungle tract where it is intended to introduce tusser silk-rearing, a few thousands of these wild cocoons should be procured in Birbhum, Manbhum, and other districts where they are more commonly found, and hung up on high trees in the new locality. The foundation of the tusser silk-rearing industry is the possibility of obtaining wild tusser cocoons with ease. The principal hindrance to tusser cocoons being formed in the wild state is the presence of insectivorous birds. In those districts where tusser-rearing is practised, insectivorous birds are not at all common. The reason for this probably is the destruction of these birds by the Sonthals. They are always killing them with bows and mud pellets. Whether the tusser-rearing industry can be easily introduced into a locality or not is to be judged principally by the circumstance just alluded to. It is easy to watch thousands of silkworms sitting under one tree; but to watch a wild worm here and a wild worm there for the purpose of securing them for seed is impossible. Where birds are not plentiful it is not very hard to get wild tusser cocoons in jungles.

175. *Gathering of Seed-cocoons.*—When an arrangement has been made of killing insectivorous birds and of distributing a few thousands of wild tusser cocoons in a particular jungle, it will not be found very difficult afterwards to gather wild cocoons for seed. Sonthals in procuring fuel, potherbs, and roots in jungles are always on the look-out for seed-cocoons. These remain hid among leaves on the tops of high trees. The colour of the tusser silkworm is green and indistinguishable from that of leaves. It is almost impossible, therefore, to descry a tusser silkworm on a high tree for one standing under its shade. So when Sonthals are on the look-out for seed-cocoons, they walk looking downwards, not upwards. When they see droppings of the tusser worm on the ground, then only do they climb one or two trees in search of wild worms or cocoons. It is only when the droppings are larger than round pepper that they do the climbing, as then they know the worms are either ready to spin, or they have already spun, cocoons. Such full-grown worms or recently-made cocoons they take home and keep for seeding.

If the cocoons they have procured contain chiefly female insects, they put the female moths out when they emerge outside at night, and early in the morning they find a sufficient number of males also come somehow or other. As female moths are larger than male moths, the cocoons which contain the females are somewhat fuller in size. So when Sonthals look for wild cocoons they look out chiefly for full-sized cocoons as from these emerge a larger proportion of females. As male moths are freely (almost supernaturally) obtainable, a larger proportion of females does not result in any loss to the proportion of seed. The seed from the wild stock can be kept up for three, four, or more generations successively in a healthy condition.

176. *Food-plants.*—As a rule the ordinary Bengal tusser worm (*Antherœa mylitta*) will eat the leaves of any tree on which it is put from the very first and make cocoons also. But it will not as a rule eat the leaves of one kind of tree after it has been eating those of another kind for a number of days. It does not eat any strong smelling or bitter leaves, or leaves otherwise repulsive to taste, touch, or smell. It does not eat the leaves of low-growing bushes, nor those of branches brought indoors. It is not found to eat leaf in any other than the way in which it is naturally accustomed to eat, *i.e.*, in uncovered places and in high situations. The worms can, however, be reared in a fashion, and made to spin cocoons also, if they are placed on branches hung up high in the verandah, water sprinkled on them occasionally with a garden tin-can fitted with a rose (that the worms may imagine it is raining), and fresh branches put daily in contact with the older branches. The following are the commonest trees of tusser-growing localities the leaves of which are not repulsive either to taste or smell. The tusser worm is found to eat the leaves of all these trees and make cocoons on them:—(1) *Asan* or *Sáj* tree (Terminalia Tomentosa); (2) the *Sâl* tree (Shorea Robusta); (3) the *Arjuna* tree (Terminalia Arjuna); (4) the Myrabolam tree (Terminalia Chebula); (5) the *Baherá* tree (Terminalia Bellerica); (6) the *Sidha* tree (Lagerstrœmia Parviflora); (7) the common *Baer* or Plum tree (Ziziphus Jujubier); (8) the *Jeol* tree (Odina Wodier); (9) the *Kend* or

Bengal Ebony tree (Diospyros Tomentosa); (10) the *Mahul* or *Mahuá* tree (Bassia Latifolia); (11) the *Kambhi* tree (Careya Arborea); (12) the *Dhák* tree (Anogeissus Latifolia); (13) the *Lodh* tree (Symplocos Racimosa); (14) the *Simul* tree (Bombax Malabaricum); (15) the *Karamcha* tree (Carissa Carãndas); (16) the *Jambun* tree (Sizizicum Jambolanum); (17) the *Peepul* tree (Ficus Religiosa); (18) the *Phurush* tree (Lagerstrœmia Indica); (19) the Castor-oil plant (Ricinus Communis); (20) the Teak (Tectona Grandis); and (21) the Country Almond tree (Terminalia Catappa). In tusser-growing localities, the worms are found to eat the leaves of some newly-introduced tree and to make cocoons on them : *e.g.*, the mango, the mulberry, and the *sisu*. Of all the trees mentioned above, the *asan* is best adapted for rearing the tusser, as it stands a good deal of lopping. It is necessary to lop off the branches of trees when the worms require to be removed from one tree to another.

177. *Emergence of Moths.*—The seed-cocoons, either wild or domesticated, should be hung up in an open place. The moths do not all come out at once of these cocoons. Some come out within a fortnight, but others after two or three months, or even six or seven months. From cocoons which are of light colour, and which possess long peduncles, the moths emerge within a short time after they are spun; but large and dark-coloured cocoons. which have short peduncles, the moths emerge from after six or seven months. It is in this way that there are no definite seasons for rearing the tusser worms. Large and small worms and cocoons of the tusser can be seen at all seasons. There are, however, three principal tusser-rearing seasons or *bunds*. The Sonthals call them the "Dhuriá," the "Barsáti," and the "Jadui" *bunds*. As some moths come out of cocoons irregularly at all seasons, there are several minor *bunds* besides the three principal ones. If seed-cocoons are secured in October, a few moths will be seen to emerge every now and again from November to January; but the major portion of the moths will come out in February. In cold hill countries, moths come out of tusser cocoons only once in the year. In Lower Bengal the tusser worm is reared during all the months of the year, and in large quantities at three recognized periods. The rainy season, however, is the principal one for rearing tusser.

178. *The Dhuriá Bund.*—For this crop of tusser cocoons operations commence in the middle of February, as at this time moths emerge from most of the seed-cocoons of the previous year's spinning. The moths lay eggs on the day following the night in which they emerge. The eggs hatch after eight days. The worms eat leaf for two months, and then make cocoons. The cocoons of the *Dhuriá bund* are therefore formed in April.

179. *The Barsáti Bund.*—The long-stalked and small-sized cocoons of the *Dhuriá bund* are reserved for seed for the *Barsáti bund.* The insects inside such cocoons are the feeblest. The object of using the feeblest cocoons for seed for the principal *bund* of the year is this : moths from hardy cocoons come out very irregularly, *i.e.*, instead of coming out at the right time for the *Barsáti bund,* they come out before the *Jadui* or the next *Dhuriá bund,* or at irregular times altogether. The hardy cocoons are almost black in colour, and their peduncles are very short. These cocoons are called "Mugo" cocoons. The smaller-sized and lighter-coloured cocoons, such as are used for seed for the *Barsáti bund,* are called "*Láryá*" cocoons. The tusser worms getting diseased within a very few generations is to be attributed chiefly to the exclusive use of *Láryá* cocoons for seed for the *Barsáti bund.* Moths emerge from the *Láryá* cocoons of the *Dhuriá bund* about the 20th of May. The moths come out at night and lay eggs on the following day. The eggs hatch after eight days. The worms remain on trees for a month and a half, and spin cocoons in the middle of July.

180. *The Jadui Bund.*—The *Láryá* cocoons of the *Barsáti bund* again are used for seed for the *Jadui bund.* The object of selecting out the *Láryá* cocoons for seed for this crop also is to get the moths to emerge all at the same time. The moths come out of these cocoons about the first week of August at night, and lays eggs on the following day. The worms eat leaf for two months fully, and spin cocoons about the middle of October.

181. *Manipulation.*—It is in the caterpillar stage that the tusser insect requires to be kept outdoors on trees for day and night. In the other stages it can be kept indoors. When large quantities of seed-cocoons have to be kept, they should

be kept hanging in clusters on the top of a pole in the open yard, and not inside the house. To protect them from sun and rain, a straw thatching is put over the cocoons at the top of the pole. When one or two moths are seen to have come out, the pole is taken down and the cocoons strung on to the bamboo part of a number of bows, and these slung down with ropes from trees in such a number that when the ropes are raised the bows become lowered, and when the ropes are lowered the bows become raised. The moths begin cutting out at 9 or 10 P.M. The male moths fly away, the females remaining quietly on the bows. The females usually come out first of the cocoons. From midnight till 3 A.M. the males will be seen coming to the bows. As a rule, the males that flew away from the bows after coming out of the cocoons do *not* return to these bows, but other strange males. In the morning the bows with the moths on them are brought indoors. In the afternoon the female moths (which are larger in size) are put in closed vessels made with large-sized leaves pinned together with hard leaf-stalks. As a rule two female moths are put into each leaf-cup, the mouth of the cup being fastened with leaf-stalks. The leaf-cups remaining inflated, the moths make attempts at flight, and at each attempt lay a few eggs. In the natural state the moths fly from one tree to another and lay eggs, very few on each tree. The leaf-cups containing moths emerging on different dates are kept separate. The moths nearly finish laying eggs in the night following the afternoon when they are enclosed in the leaf-cups. Five days after the eggs are laid, the cups are unfastened, the moths thrown away, and the eggs carefully picked or scraped out. The eggs are then gently rubbed between the palms of the two hands, and the dust and down on them blown away. The eggs thus made clean are put into little cups, also made with leaves. These cups are attached to leaves of growing trees with leaf-stalks. To prevent rain-water penetrating the cups or strong wind upsetting them, one or two more leaves of the growing tree are lowered and pinned on as a cover to the former leaf to which a leaf-cup is attached. Ants are kept off the tree by means of a circle of *bhelá* oil round the trunk of the tree. The worms hatch out of the eggs on the eighth day. From this time onwards a person requires to sit under the tree and watch the worms all day. The chief enemies of the tusser silkworm are birds, ants, bats, wasps, and jackals. The person watching the worms should have bird-lime and a bow ready at hand. While watching the insects one can weave nets or spin threads sitting underneath the tree. It is convenient attaching the leaf-cups containing the eggs to small-sized trees, as then the branches can be lopped off when the worms have finished eating their leaves, and easily removed to other trees.

182. *Disease.*—The leaves of the trees, if too succulent, or if the heat be too intense, at the time the tusser worms are at their last stage, they die off in great numbers from grasserie, chiefly during the *Barsáti* and *Jadui bunds.* The exciting cause of the disease is the abnormality of the season, but the predisposing cause is the use of *Láryá* cocoons for seed. Tusser worms thrive best when it rains every now and again. Absence of rain and excess of rain are equally injurious to the weaker tusser worms. Sonthals rear the largest quantity of tusser silkworms in the rainy season, as then there is an abundant supply of succulent leaf in jungles—a condition very helpful to the production of large-sized cocoons. But the atmospheric conditions of the rainy season are not altogether favourable to the healthy growth of the insect.

183. *Rearing of Bharuá or Inferior Cocoons.*—Sonthals call all the wild cocoons inferior to the tusser by the generic name *Bharuá.* When for some reason or other they rear these inferior cocoons (such as the Attacus Atlas, the Actias Selene, &c.), they follow exactly the same method of rearing which has been described for the tusser. These inferior silkworms which they sometimes rear are also polyphagous like the tusser worm.

CHAPTER V.

Rearing of the Eri Silkworm.

184. *Varieties.*—Some inferior varieties of silkworms which make cocoons eat the leaf of the Eranda or castor-oil plant (*Ricinus communis*). These cocoons cannot be reeled, *i.e.*, one uninterrupted length of fibre cannot be drawn out of each

cocoon. They have to be combed and carded and spun into thread, like cotton or wool. The Eri silk fibre is stronger than woollen, cotton, or even mulberry silk fibre. There is a kindred variety of cocoons called the Attacus Atlas (Fig. 24).

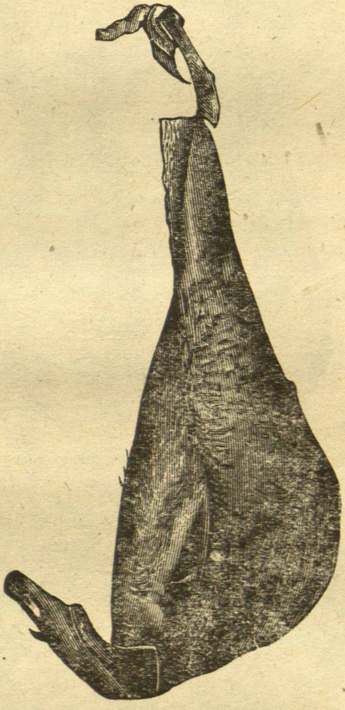


FIG. 24.—Attacus Atlas Cocoon.

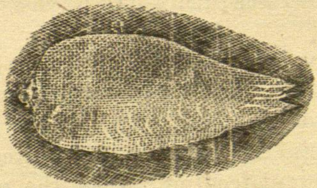


FIG. 25.—Attacus Ricini, Eri or Endi Cocoon.

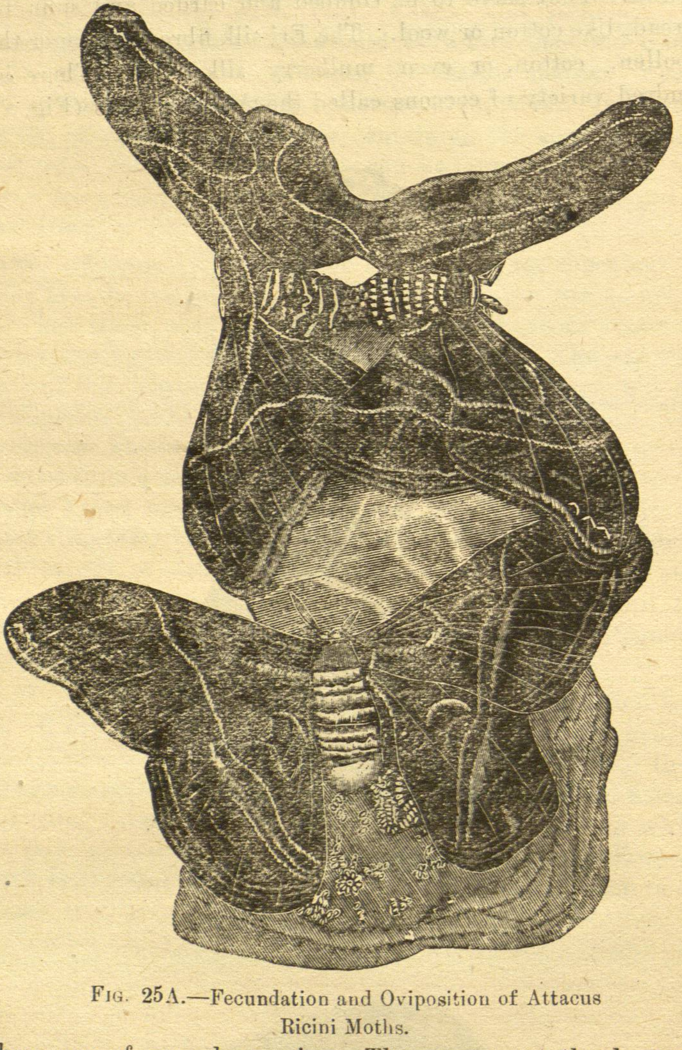


FIG. 25A.—Fecundation and Oviposition of Attacus Ricini Moths.

These are of very large size. The worms eat the leaves of various kinds of trees, like tusser worms, but they also eat the leaves of the castor-oil plant. To call the ordinary Eri silkworm Attacus Ricini is, therefore, not quite correct, as Ricini means castor-oil-plant-feeding. Like the ordinary Eri silkworm, the Atlas silkworm also makes cocoons fed on the leaves of the castor-oil plant only. Though the Attacus Atlas cocoons contain eight or ten times as much silk as Eri cocoons (Fig. 25), they are not so valuable. The fibre is inferior in softness and elasticity. The remarks about the Eri silk that will follow apply only to the Attacus Ricini, and not to the Attacus Atlas. Among ordinary Eri cocoons there is also considerable divergence in the quality of fibre. A lot of Eri cocoons present a certain proportion of deep brown or brick-coloured cocoons. The less the proportion of these brick-coloured cocoons in a sample, the better is its quality. If only the lightest coloured cocoons are selected each time for seed, five or six successive rearings help to weed out completely the admixture of the brick-coloured cocoons and to establish a stock of pure white cocoons. A larger quantity of Eri cocoons is exported from this country than woven Eri cloths. If the dirty-coloured cocoons can be eradicated, the export of Eri cocoons can be considerably increased, and larger prices also obtained for them. To bleach the dirty-coloured Eri fibre white and to dye it are both difficult and costly. The introduction of a white stock into those localities where the Eri cocoons are reared would be an important undertaking. The wild Eri silkworm (Attacus Cynthia) spins small dirty-coloured cocoons ; and it is no doubt that, by domestication, the size and colour have been improved considerably already.

185. *Disease of the Eri Silkworm.*—As the mulberry silkworm is subject to pebrine and flacherie, so is the Eri silkworm of Assam. In fact, these diseases are prevalent in Assam to such an extent that they are recognised as the chief obstacle against an increased production of these cocoons. The Eri silkworms of Bogra and of Cooch Behar are hardier, and pebrine has not yet been able to establish its sway among them. The rearing of the Eri silkworm is one of the principal industries in Assam. This industry can be conserved and improved (1) by the adoption of unmixed white cocoons as the staple, and (2) the microscopic selection of seed. The way to eradicate disease among the Eri silkworms in Assam is to import seed from some locality where little or no pebrine is

noticed on microscopic observation, and also to establish a number of *grainages* in Assam, where the healthy seed can be perpetuated by microscopic selection. The method of selecting Eri silkworm seed is exactly like that recommended to be followed in the case of the mulberry silkworm seed. The worms from selected seed can be protected from infection of diseases exactly in the same way as mulberry silkworms are protected. The Eri silkworm can be protected from the parasitic fly also exactly in the same way as the mulberry silkworm.

186. *Value of Eri silk.*—The Eri silk cloth, though coarse and rough in appearance, possesses certain special qualities. No other kind of cloth proves so lasting. The more it is washed, the softer and more decent-looking it gets. The pieces of Endi or Eri cloth that could be had in Assam for Rs. 3 or Rs. 4 each 50 or 60 years ago are now sold for Rs. 15 to Rs. 20 each in the Calcutta market. The appreciation of the value of Eri silk is chiefly due to the extensive use of this cloth by Europeans in the hot weather. In Assam itself English cotton cloth is supplanting the use of Eri cloth, on account of the dearness of the latter article. Rupees 30 to Rs. 60 per maund can be had for pierced Eri cocoons in the Calcutta market. If pure white Eri pierced cocoons could be exported to Europe, Rs. 100 or more per maund could perhaps be realized. Carderies for spinning pierced Eri and Tusser cocoons have been established in Europe only of recent years. Messrs. Lister & Co's. carding mills are the most famous in England. In Italy Messrs. G. Bonacossa & Co., of Milan, have established a large carderie in the little village of Meina on Lake Maggiore. This Company is most anxious to secure white Eri cocoons from India. They buy waste silk and pierced cocoons of all kinds.

187. *Increasing the Produce.*—For want of effort the increased demand for Eri cocoons and Eri cloth has not resulted in an increased production. The rearing of the cocoons and the weaving of the cloth are both done by the poor peasantry. They do not know much about the increased demand or

increased prices. It is their *mahajans* (or money-lenders and shopkeepers) who have information on these matters. The *mahajans*, either by lending money to cultivators or in exchange of other articles, secure from each small quantities of Eri pierced cocoons, or spun thread, or woven cloth. They buy them very cheap, and when they get large quantities of these articles accumulated, they send them to Calcutta instead of selling them in the local *háts;* while they import various other articles of merchandise from Calcutta for sale in the local *háts*. Women of the cultivating class do the rearing of Eri worms, or spinning of thread, or weaving of cloth in their leisure hours, with the main idea of paying off the *mahajans'* debts. This kind of work, as it goes on with ordinary domestic duties, is never felt hard by the women, and whatever they get in return for it they look upon it as pure profit. For women, it is not always convenient to work outside their houses. They can easily feed silkworms, or spin thread, or weave cloth in their houses and look after their children at the same time. After a whole year a woman produces only about Rs. 10 or Rs. 12 worth of cocoons, thread or cloth; but they do not look upon this as loss. That is how *mahajans* come to secure cocoons, thread, and cloth so cheap. If large plantations of the castor-oil tree have to be made by hired labour, each acre would cost at least Rs. 30 per annum. From an acre of castor-oil trees one can get 60 to 90 seers of pierced cocoons per annum. The price of this quantity of cocoons is only about Rs. 60. If in addition to the hired labour employed in the maintenance of the plantation one employs it also in the rearing of worms, one will not find Eri silk-rearing of much profit. As it is, the castor-oil plant occurs in most localities (almost in every village homestead). The villagers can easily rear small quantities of Eri worms, and utilize the leaves of these plants. To grow small quantities of various kinds of crops is more profitable than to grow a large quantity of one kind of crop only, as is the rule among cultivators of this country. Be it paddy, or silk, or sugarcane, if reliance is placed on one crop only, drought or inundation or a particular kind of insect pest may destroy it all. If reliance is placed on small quantities of several crops, an accidental cause cannot affect them all, though it may ruin one or two of them. This method of cropping cannot ruin a cultivator and involve him hopelessly in debt. Women cannot do any other kind of work so easily along with their domestic duties as they can do silk-rearing. Of all silkworms, again, the Eri silkworms are most easily reared, and they eat for the shortest period of time before making cocoons. Thus, a few castor-oil plants being grown close to the homestead, the women folk can easily bear their share of the domestic burden of a peasant family. It is, therefore, desirable that ordinary cultivators should take to rearing this class of silkworms. Where the rearing of the Eri silk already prevails, there also the study of this subject by schoolboys may result in the amelioration of the industry. It is in the following three ways that the Eri silk industry can be principally improved by instruction :—(1) When rearing of the worms is done within a year after a previous rearing, the rearing-house and the *dálás* and other appliances should be disinfected with sulphate of copper solution and sulphur fumes. (2) Rearing should be done either from microscopically examined seed (cellular seed) or seed only one generation removed from microscopically examined seed (industrial seed). (3) White Eri cocoons should alone be reared. The use of the microscope, of sulphur, and of sulphate of copper has been described in Part II of this book.

188. *Special Advantages in rearing the Eri Silkworm.*—It is easier to rear the Eri than the mulberry silkworm. The former eat leaf for 15 to 30 days after hatching out before they spin cocoons. In very hot weather they spin after 14 or 15 days only, while mulberry silkworms take about 20 days. A second advantage in rearing the Eri silkworm consists in cattle not caring to eat the castor leaf if they get anything else. The castor plant thus grows under comparative neglect. The third advantage in rearing the Eri silkworm consists in the fact that it is admirably adapted for learning sericulture. One can readily understand the various stages the silkworm goes through by rearing this species of worms—that is, the moulting

stages, when they do not eat, the moth stage and how they lay eggs at this stage, and the incubation stage. For one utterly unaccustomed to silkworms, it is advisable to rear the Eri worms for a few times before going on to rearing the mulberry silkworms. Attempts to rear the mulberry silkworms after reading a description of them in a book often result in failure at the very outset, when the worms are very small, and are mismanaged at the first moult, this moulting not being so easy to judge. As the Eri silkworms are larger and hardier, they are not easy to mismanage, and they afford an excellent material for learning the habits of silkworms generally.

189. *Manipulation.*—Mulberry silkworms and Eri silkworms can be both reared almost in the same way. The day the little worms come out of the eggs, tender leaves should be spread over them. These leaves with the worms on them should be removed to a separate *dálá* three or four hours afterwards. The worms should be fed five times a day at the regular hours. The *dálás* are to be cleaned daily or every other day with the help of thread nets, such as are used for catching small fish. The worms that will be found lying motionless on lifting up a net for the purpose of cleaning should be looked upon as moulting worms. These should not be disturbed or fed, but the *dálá* on which they are should be left in a separate place. Like mulberry silkworms, the Eri silkworms also moult four times during the caterpillar stage, but they do it at the shorter intervals of three or four days each time. When the worms are small they should be given chopped-up leaf. When they get big they need not be given chopped-up leaf. In the last stage particular attention should be paid to feeding the worms on large-sized, vigorous, thick and fresh leaves. If they are fed on thin and small leaves at the last stage, they make poor cocoons. The little worms when they first come out of eggs are of a mixed black and yellow colour. After they moult or cast off their first skin, they become greenish white. When they go to moult again, they become slightly yellowish. Before they make cocoons they become either cream-coloured or a mixture of white and

rich green colour. Eri silkworms eat more leaf than mulberry silkworms. They should, therefore, be fed at least five times a day from the first to the last day. To get a thorough knowledge of Eri silk-rearing one should read Parts I and II of this book carefully.

190. *Cocooning.*—Eri silkworms cannot be so easily picked out from *dálás* when they are ripe for spinning as mulberry silkworms can be picked out. A *chandraki* is not therefore such a suitable appliance for cocooning in the case of the Eri silkworm. The arrangement for cocooning which is suitable for European silkworms is best adapted for this species of silkworms also. In other words, dry twigs should be tied with strings at regular intervals on to the posts and cross-pieces of the *mácháns*. When the worms are ready to make cocoons they leave the *dálás* themselves and get inside these bundles of twigs, where they make cocoons. Some of the worms, under this arrangement, will make cocoons in the litter. Such cocoons are not to be regarded as inferior for spinning. Mulberry cocoons when spun in the litter cannot be properly reeled, but spun into coarse thread like pierced cocoons are spun. But as all Eri cocoons are unreelable, and are spun into coarse thread, it is of no consequence if some worms make their cocoons in the litter. But cocoons which are spun outside the *dálás* should alone be reserved for seed, as worms that go out of the *dálás* are presumably stronger. The whitest cocoons and such as are richest in silk should also be selected for seed.

191. *Seeding.*—Moths from mulberry cocoons come out 8 to 20 days after they are spun; but those from Eri cocoons take 15 to 30 days to come out in Lower Bengal, *i.e.*, about 15 days in the hot weather and about 30 days in the cold. The seed-cocoons should be strung up in threads or kept spread out in one thin layer in bird cages or wire boxes. The moths emerging remain inside the cages, or if the cocoons are kept strung up, the moths remain sitting quietly on those cocoons. The few male moths that do fly away usually return after a while. If it is intended to seed the moths cellularly for microscopic selection, the female moths should be covered up

separately, 10 or 12 hours after their emergence from cocoons, with little earthen cups. If it is intended to seed the moths industrially, they should be left to lay eggs on the strings of cocoons or in the cages. Fig. 25 A represents fecundation and oviposition of the Attacus Ricini moths. The eggs are laid singly and in clusters as shown in the figure. Five or six days after the moths have come out the eggs should be carefully picked or scraped out. If microscopic selection is done, the moths should be examined from the fifth day, the earthen cups being taken up one after another, and after the examination the eggs selected free from disease should alone be collected. Other eggs and all the moths should be either burnt or buried in the dung heap. The pierced cocoons should then be taken out of the rearing-room. The room, the *dálás*, and all other appliances should be washed with sulphate of copper water, and half a seer of sulphur burnt in the room in the proper manner. The eggs also should be given a dip in the sulphate of copper solution, dried immediately afterwards, and taken into the disinfected room. The eggs hatch 8 to 15 days (8 in the hot and 15 in the coldest season) after they are laid. The eggs require simply to be kept thinly spread out on a *dálá* for the worms to come out of the eggs without any difficulty. When the eggs once begin to hatch, all the worms out of that lot come out in 3 or 4 days. If chopped-up leaves are put on the eggs, the intervention of a little piece of mosquito curtain net is required.

192. *Pierced Eri Cocoons.*—As the Eri cocoon cannot be reeled off, the moths should be allowed to come out of the cocoons in every case. It is a mistake to kill Eri cocoons by exposing them to the sun. Green Eri cocoons, *i.e.*, such as have live chrysalides inside them, go 500 to 800 to a seer. If they are killed and dried in the sun, 1,500 to 2,500 go to a seer. When they are not killed, but when moths are allowed to escape out of them, 4,000 to 7,000 get to a seer. If it is a very good kind, 3,000 pierced cocoons only go to a seer. Now, it should be remembered that 7,000 Eri cocoons with chrysalides do not yield any more silk than the same number without

chrysalides. The custom that prevails of sunning the Eri cocoons is, therefore, a bad custom. When a maund of pierced Eri cocoons may be valued at Rs. 100, a maund of Eri cocoons with chrysalides inside them may not fetch more than Rs. 20. If the moths are allowed to cut out of the cocoons, they can be actually utilized for various purposes. Ducks and domestic fowls of all kinds may be fed on them. They may be made to add to the strength of the manure heap if they are buried in it. Kukis and other races eat the chrysalides extracted from the cocoons, after cooking them into curries. Thus in one way or another the chrysalides or moths may be made some use of.

193. *The Litter.*—The droppings and refuse leaf of the *dálás* on which Eri worms are kept should be thrown in the dung pit and there rotted for manure. When one is counting the various advantages of silk-rearing, one should never leave this out of account—that silk-rearing is an excellent way of getting manure; that the seed of the castor-oil plant yields an oil which is used for physic as well as for lighting and lubricating machinery; and that the castor-oil cake is a rich manure should also be kept in mind. In Jessore and some other districts cultivators usually have a number of castor-oil plants close to their homesteads for the purpose of getting oil only. They can easily do rearing of the Eri silkworms also. If they take to rearing the Eri silkworm, they are likely to attempt the rearing of the more valuable mulberry silkworm also in time.

194. *An Obstacle to rearing the Eri Silkworm.*—In April and May, when the blazing sun renders the air excessively dry, Eri eggs usually shrivel up, and do not hatch. In those localities where it rains frequently at this season, the Eri eggs hatch without difficulty at all times of the year. It is, therefore, necessary to import seed annually from Assam, Cooch Behar, or some other cool or wet locality once every year at the beginning of the rainy season. By special arrangements—that is, by daily plastering the floor of the rearing-room with a wet rag, by rearing the worms in deep, moist underground rooms, and by feeding the worms six or seven times a day—the Eri eggs can be made to hatch even during the two hot and dry months of the year.

PART IV.

MANUFACTURE AND COMMERCE.

CHAPTER I.

WASTE SILK.

195. *What is Waste Silk?*—The following substances are comprised under " waste " or waste silk:—The *Phensua* or *Frisson,* the loose silk adhering round cocoons, which is separated out when one gathers cocoons from the spinning screens (*chandrakies*). The *frisson* cannot be regarded as a portion of cocoons, and it is not sold with cocoons. (2) The *chhenia* or flimsy cocoons. These also are sold separately along with *frisson* and not with good cocoons. (3) The *jhut or* ribbon-waste, *i.e.,* bundles of silk fibre that come out and get rejected in the reeling basin in getting the clean ends of boiling cocoons when they are beaten with a clump of sticks for this purpose. (4) The *telette or topá,* that inner portion of a cocoon which cannot be reeled off, but which sinks in the basin with its chrysalis. (5) *Double cocoons, i.e.,* those made jointly by two or three worms which cannot be reeled. (6) *Pierced cocoons,* that is, cocoons that have been used for seed, and out of which moths having come out, the continuity of their fibres has been broken. Such cocoons cannot be reeled. (7) Pierced cocoons of the Tusser. (8) Eri, and other inferior cocoons.

196. *Use of Waste in this Country.*—Pierced mulberry and Tusser cocoons and Eri cocoons have been utilized for textile purposes in this country from time immemorial. *Matká* cloths are made out of pierced mulberry cocoons in Murshidabad, Rajshahi, and Malda. At Vishnupur, in the district of Bankura, a coarse kind of cloth, called *kethé,* is made out of pierced Tusser cocoons. From Eri cocoons " endi " cloths are made in the northern districts of Assam, also in Rangpur,

Dinajpur, Purnea, Bogra, Jalpaiguri, Cooch Behar, the Eastern Terai of Nepal, Chittagong, Gaya, Shahabad and Puri. Coarse thread for making *matká* cloths is spun out of pierced mulberry cocoons, after kneading them with a paste made by pounding peas with water or with ordinary clay. The cocoons are soaked in this paste for a little while, and then one by one they are taken up with the left hand, a strand of thread drawn out of it with the thumb and index finger of the right hand, attached to a spindle, and kept twisting with the revolution of the spindle. The thread, when twisted, is gathered in at the bottom part of the spindle, and more thread drawn out of the cocoons (Fig. 26).

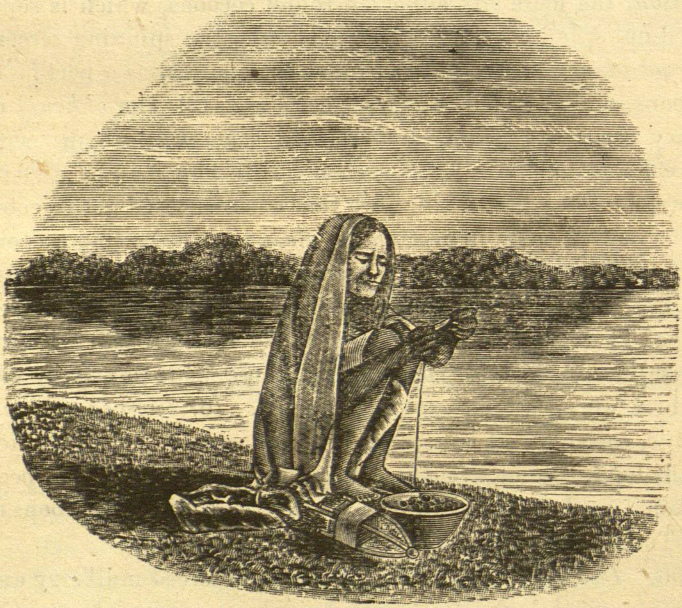


FIG. 26.—Matka-spinning.

When the day's spinning is done, the thread is taken out of the spindle and gathered on to a *látái* (a pyramidal bobbin made out of bamboo laths). After four or five days, about 4 ounces of thread accumulate on a *látái*. This quantity is taken out. It forms a "bundle." When several bundles of *matká* thread accumulate, they are usually taken for sale to a local *hát.* A seer of *matká* thread sells for Rs. 3 to Rs. 6. Pierced cocoons are usually spun into *matká* thread by very old women, such as can do scarcely any other work. They earn a rupee or so per month by this work. To make a seer of *matkâ* thread the woman requires to buy about 10 *káhans* of pierced cocoons. The price of this quantity of cocoons is about Rs. 2-8. She spins about 2 *tolas* (less than 1 ounce) of thread out of 4 *puns* (320) of cocoons *per diem.* In other words, to make a seer of thread it takes her about 40 days. Her only other expense consists in buying about 1 anna worth of dry peas (shelled into *dál*) which lasts her for the 40 days, less than half a pie worth of *dál* being used daily. If clay is used instead of pea-paste, this expense also is saved. Village women spinning *matká* thread indoors along with their usual domestic work find they can earn a few annas or a rupee every month without going out of their domestic circle. *Matká* thread is used for weaving either in a raw state—that is, before it is subjected to a bleaching operation—or after bleaching.*

197. *Spinning of Eri Cocoons.*—Pierced Eri cocoons are not so easily spun as pierced mulberry cocoons. They require either to be boiled for an hour or two in water to which ashes have been added, or steeped in water to which vegetable or animal pepsine is added as ferment. They are afterwards washed well, dried, and then spun in the same way as mulberry cocoons. The ashes just spoken of are obtained by drying and burning banana leaves, or tender leaves and branches of any kind of plant. Ashes of indigo refuse (2 ounces being used for every seer of pierced cocoons) give very good result. The ashes are mixed up with water, and the Eri cocoons are kneaded in this water. The cocoons are then tied up loosely in cloth, a bit of stone being put along with the cocoons, and the bundle of cocoons put inside some vessel. The vessel is filled with

---

* Babu Akshay Kumar Maitra, Secretary of the Sericultural School of Rampur Boalia has kindly informed me that he has succeeded in bleaching *matká* thread nearly white by the following process:—The thread is ungummed by passing it through a 5 per cent. solution of hydrochloric acid, washed well, boiled in soap bath, and washed again. It is then boiled in a weak solution of bicarbonate of soda, and afterwards passed through a very dilute solution of sulphuric acid.

water, a cover put on, and boiling allowed to go on for an hour or two, water being added from time to time when it goes down too low. The vessel is then taken down from the fire, and when it gets sufficiently cool to enable one to handle the cocoons without difficulty, the bundle is taken out, and the cocoons kneaded hard with both hands. While the kneading is going on, clean water is poured on the cocoons until the water kneaded out comes out quite clean. The excess of water being expelled, the cocoons are spread out in the sun to get dry, and then stored up, a few *puns* being spun daily with the help of a spindle or a wheel, after wetting the cocoons with water. For dissolving the gum on Eri or Tusser silk with the help of digestive ferments, (1) the pulp of any ripe fruit, preferably papya, or (2) the viscid mucous obtained by scraping the cleansed mucous membrane of the fresh stomach of a goat, sheep or pig with a blunt knife, may be used. Spinning Eri pierced cocoons is not any more remunerative than spinning mulberry pierced cocoons. *Endi* thread is stronger than *matká* thread, and it usually sells dearer. Pierced Tusser cocoons are spun more easily than Eri cocoons, but these also require to be boiled in water, mixed up with ashes, or softened by the use of ferments, before thread can be drawn easily out of them. Of all kinds of silk cloths procurable in this country, *kethés* are the cheapest and fairly durable. A piece of *kethé*, 10 yards long and 1 yard wide, can be purchased for Rs. 6. A complete suit of *kethé* cloth costs only about Rs. 5, and it can easily be worn even by the genteel classes.

198. *Use of Waste in Europe.*—The art of utilizing silk-waste was unknown in Europe forty-five years ago. But during these forty-five years the use of silk-waste has been steadily increasing. The waste is cleaned and washed by various processes, them combed and carded, and very beautiful thread spun out of it. Satins, the cheaper kinds of velvet, and other beautiful looking textiles are made out of spun silk. The machinery employed for making spun silk is very costly, more so than the machinery used for weaving, etc. It is only with the help of public-spirited rich men that such machinery can be introduced into this country.

CHAPTER II.

Reeling of Silk.

199. *The Oven.*—In Part II of this book it has been said that cocoons require to be killed by heat, or with carbon bisulphide, before they are reeled. Even when they have been killed they require to be steamed, except in the rainy weather, when cocoons killed in the sun are exposed to the action of heat and moisture simultaneously, which does away with the need of subsequent steaming. The combination of heat and moisture makes the fibres on the cocoons to swell up and become loose and easily reelable. Even in the rainy weather it may be necessary to bake the cocoons in a steaming oven, simply to kill them, when the rays of the sun or carbon bisulphide are not available for this purpose. At other seasons, the object of putting cocoons into an oven is not simply to kill them. They are, therefore, steamed in the oven, even when they have been killed in the sun, before they can be properly reeled. Where large quantities of cocoons require to be killed, steaming ovens must be provided. When small quantities of cocoons only have to be reeled, the steaming can be done by introducing the cocoons in a basket or in an earthen vessel having holes at the bottom, and putting the basket or the earthen vessel on the reeling basin where water is boiling, the basket or the earthen vessel being covered up with a blanket, to keep the steam in as much as possible. A properly constructed oven has this advantage, that the temperature inside it can be made to exceed 100°C, while the temperature of the steam got from the boiling basin is ordinarily 100°C. Exposure of cocoons to a temperature of 160°C for 5 minutes kills them effectually. A short exposure of living cocoons to 100°C leaves those inside a heap alive. Moths coming out of such cocoons afterwards make them "waste." Killing cocoons in the sun in the rainy season does not do any harm to the silk fibre; but in those seasons when the air is naturally dry, killing the cocoons by exposure to the sun lessens the elasticity of their fibre. Cocoons should, therefore, be killed in these seasons either in a steaming oven or with carbon bisulphide. The kind of ovens

constructed in this country in connection with filatures is not altogether suitable for the baking of cocoons. These are hemispherical in shape, constructed with bricks, and have a small removable door in front of each. They are first heated with fuel burnt inside. The fire is then extinguished by sprinkling water from outside, the charcoal and ashes being removed immediately afterwards, and cocoons arranged in baskets put in. The little movable door is then fastened on, and the cocoons kept inside in the hot and steamy atmosphere of the oven for 10 or 12 hours. They are afterwards taken out and spread in thin layers on *mácháns*, and distributed as required to the reelers. In Europe there is a long cavity under the oven. In this cavity is put fuel (wood or coal) and a boiler in contact with it. A tube from this boiler opens into the oven above. The cavity underneath the oven leads into a flue, which goes up the further end of the oven, then along the top, until it terminates in front in the form of a chimney. The cavity or flue going round three sides of the oven, heat is radiated into the oven from the three sides. This makes the temperature of the oven stand at over 160°C. Putting fuel inside the oven, bringing charcoal and ashes out, and sprinkling water are not required for an oven of this kind. The killing of the chrysalides is also effected in about 3 minutes in such an oven. At the entrance to the oven just described a couple of rails are fixed in the ground. A truck laden with cocoons is rolled along these rails, shut in for 3 minutes in the oven, and then rolled back. Another truck laden with baskets of cocoons is in the meantime got ready and rolled in as before. If the oven is made 12 cubits long, 3 cubits wide, and 4 cubits high, 5 maunds of cocoons can be smothered at a time, or 50 maunds (10 truckfuls) per hour. An oven like this worked for 8 hours a day can kill and steam 400 maunds of green cocoons *per diem*. Sometimes the accumulation of cocoons in a filature is so great that it seems desirable to introduce the European system of baking in this country. If a much larger quantity of cocoons arrives in a factory in one day than what has been spoken of as being easily capable of being smothered during the day, those must be baked first that are not safe to keep over for a day or two. A handful of cocoons out of each lot coming into a factory should be held close to the ear and shaken. If the shaking gives one the idea that the sound has a dry character, or when a rustling sound is heard from inside the cocoons when they are simply held close to the ear those cocoons should be killed that very day, or else moths are likely to emerge next morning and spoil some of the cocoons. If there is any doubt in the matter a few cocoons may be cut open, and it may be seen whether the chrysalides have got their eyes quite distinct, and also the contour of the wings of the future moths. If the eyes and the contour of the wings are quite plainly seen, the cocoons should be killed the same day. Steamed and unsteamed cocoons should not be kept in the same room, as this may lead to occasional mistake in steaming cocoons.

200. A more detailed description of the method followed in Bengal filatures for killing, drying and ovening cocoons may be of interest.

201. *Killing and Drying.*—A special method is adopted for killing the cocoons of the rainy *bunds* and the November *bunds*. When sunny days are available, the cocoons with live chrysalides inside them are exposed to sun for a day or two immediately after they are brought to the filature. If it is wet at the time, they are spread out in the cocoon godown, and before the moths cut out they are killed in a stove-room, called *Atas-ghar*. This room is kept hot with a big stove, the fire-place of which is at a low level and in one corner of the room, so that coal is fed from outside this room. Two pipes or flues from this stove go in a curved manner along the length of the room and up to the roof, where they end in chimneys, whence the smoke goes out. On the opposite wall to which the door of the stove is placed is a huge door through which an iron truck laden with flat trays of cocoons goes inside the stove-room or comes out of it along iron rails. The trays are made of wood or iron, and each time the truck is charged with about 600 *káhans* of cocoons in 60 or 65 trays. The cocoons are kept in the stove-room at a temperature of

150° to 160°F for four or five hours, after which they lose nearly the whole of the moisture. There is a small trap-door at one end of the room, to which a thermometer is attached, and which is opened every now and again for inspection. Out of this opening a few cocoons are also brought out with the help of a stick and cut open. Excessive heat or too long heating spoils the cocoons. In the hot weather, when two or three days' exposure to the sun is sufficient, the cocoons are not put in the stove-room. After sunning or stoving the cocoons, as the case may be, they are spread out on bamboo shelves (*máchâns*) and stirred every now and again, and after seven or eight days they are put out once more in the sun for a short time.

202. *Ovening.*—Three or four days before the cocoons are reeled a week's supply of cocoons (about 2,000 *káhans*) is ovened at once. The oven or *tundul* is a hemispherical masonry structure, hollow in the interior, having a masonry floor and a small trap-door. Wood is burnt inside this oven, and when a blazing fire has been made and the oven has become very hot, the fire and cinders are brought out, and water is sprinkled thoroughly all over the inside without loss of time. In December 12 or 14 *kulsies* of water are thus used, and in April 24 or 25 *kulsies.* In the rainy *bunds* cocoons do not need ovening, as the fibre in these *bunds* is naturally soft and open. The cocoons arranged in baskets are put inside the oven as soon as sufficient water has been sprinkled inside the oven, and immediately the trap-door is made firm. The ovening continues for 10 or 12 hours. No sunning is required after ovening, as the object of ovening is to give the cocoons a mellowness, which is lost by sunning or drying. In December the ovened cocoons are spread out on bamboo shelves, but in April they are spread out on the floor that they may not lose the mellowness through excess of drought. The ovened cocoons are distributed among the reelers.

203. *Different Systems of Reeling.*—There are mainly three systems of drawing silk thread out of cocoons :—(1) The Italian

system. When cocoons are reeled by this system, no connection is kept between a thread reeled off with its neighbouring thread. In other words, a thread instead of being " crossed " with another is " crossed " with itself with the help of two little glass wheels (Fig. 27). The advantage of this system lies in the fact that the reeling of two threads need not be disturbed when one happens to break. The disadvantage of this system consists in the fact that the little glass wheels or pulleys are liable to break from time to time. When these break there is loss of time and money. (2) The French system. This is not unlike the system of reeling in vogue in Bengal. It is necessary, when this system is adopted, to make two adjacent threads cross each other when they are reeled off (Fig. 28), but this system being simpler, it is not advisable to adopt the Italian system in Bengal. (3) The Rotellino-Galbiate system. This is more complicated than the ordinary

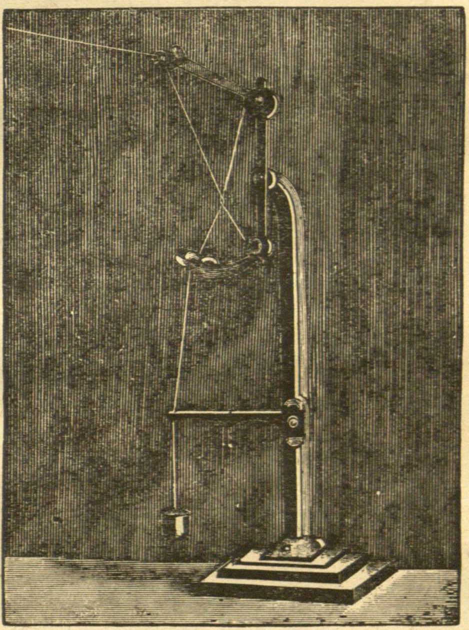


FIG. 27.—Italian System of Reeling.

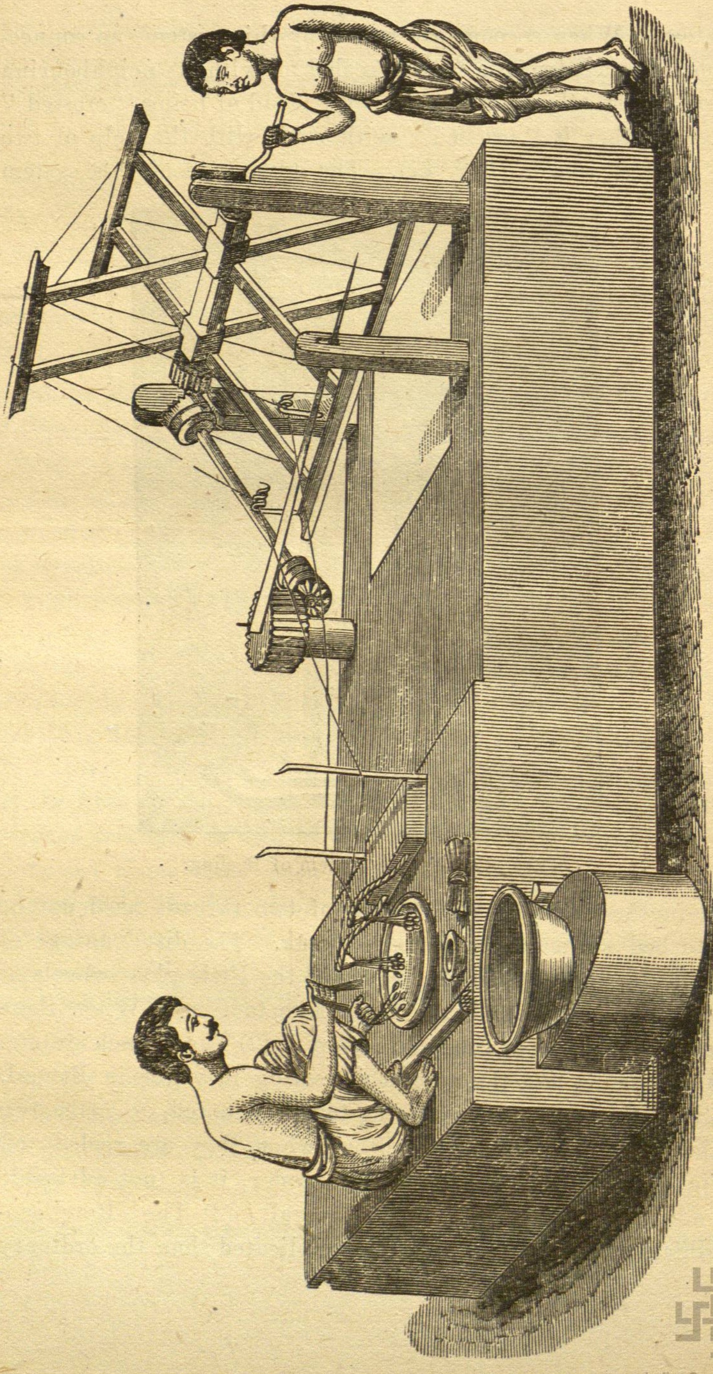


Fig. 28.—Bengal System of Reeling.

Italian system. The same thread being crossed with itself at two different places, four little glass wheels are used, which makes the mechanism still more complicated (Fig. 29). The object of adopting this complicated method in reeling silk

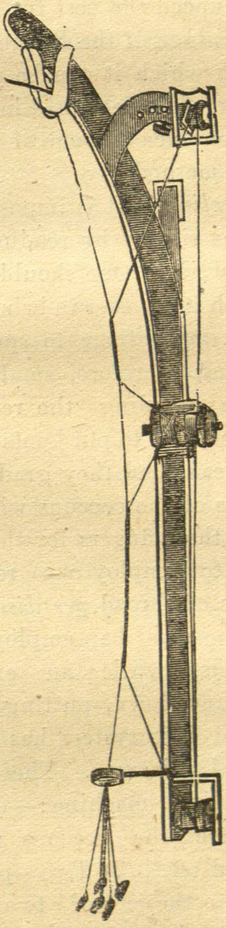


FIG. 29.—The Rotellino-Galbiate System.

is to get the original fibres or *baves* from the cocoons to be agglutinated with one another much more firmly and in a round manner by giving them two series of frictions. By this system raw silk of the best quality is, no doubt, obtained, but its complexity is its serious drawback. Taking everything into consideration, the Bengal system of reeling, which resembles the French, may be pronounced the best for Indian requirements. The most notable advantage of the Bengal system is its cheapness and the ease with which it can be put to repairs. This system of reeling is therefore described in detail. A glance at Figs. 27 and 29 will convince any one of the comparative complexity of the Italian methods.

204. *Method of Reeling.*—It is impossible to learn reeling of thread from cocoons simply by reading books. It is altogether a matter of practice. One should learn to reel silk at an early age. In youth it is easier to bring muscles and nerves under command, and apply them to special kinds of work. In silk-reeling factories, therefore, small boys and girls are usually employed for winding the reels. They begin by learning to wind the reel and to put knots on to the reel thread when it happens to break, and they gradually get to do the unravelling of the ends of the cocoons with bundles of sticks, and to throw them off their fingers for the purpose of reeling. In Bengal it is usual to employ one reeler and one winder for reeling four skeins of thread *per diem*. This is waste of labour. Two winders can be employed for winding a whole series of reels, while an extra man can be employed to walk up and down, putting knots on to threads that happen to break. This system has come into operation in some of the Bengal filatures. There are three main arrangements in a reeling machine:—(1) A basin, where hot water is kept, where the cocoons spin, and whence the fibres are carried off. (2) Two perforated porcelain eyes or discs attached to the end of two wires just above the basin. These are fixed to a block of wood, into which also are fixed vertically two brass wires or rods. The ends of a number of cocoons are passed through one of the eyes or discs

and attached to one side of the reel. The ends of a similar number of cocoons are then passed through the other eye or disc and attached to the other side of the reel. When this is done, the two lots of fibres will be found stretched in a parallel way from the basin to the reel. If the reel is turned under such circumstances, the fibres from the cocoons will work off and be laid on the reel in two loose bundles. The fibres going to form the two threads reeled off from the two sets of cocoons are agglutinated together by the two sets being crossed with each other a number of times, the vertical brass rods serving to keep the two " croisures " or crossings intact by keeping the thread separated between them. The first croisure lies between the two porcelain discs and the two vertical brass rods, and the second croisure between these vertical rods and the reel. The two sets of fibres from the cocoons form into two single threads by means of these croisures, and they are gathered on to the reel as single threads. (3) The reel. When this is turned with a handle, the fibres from the two sets of cocoons are worked off from the basin into two threads. When a cocoon has been worked off in this way, another is made to supply its place out of a lot of ready boiled cocoons. To avoid the two adjacent threads from a basin being laid on the reel exactly on the same spot, a rod or lath is made to work laterally with the help of an eccentric arrangement connected with the reel by means of toothed wheels. On these laths are fixed two glass or brass guides, through which the two threads are made to pass. The top end of these guides being twisted in the shape of corkscrews, the threads reeled off pass in contact with them without getting detached, so that the two threads are laid on a width of 3 or 4 inches of the reel when the lath moves right and left at each turn of the reel. The thread reeled off being laid in this wide manner, results in two advantages: (1) When the thread happens to break the end is more easily found out on the reel. (2) The threads get dry in the skeins while the reeling is going on (Fig. 28).

205. *Improvements in Reeling.*—(A) The basin in which cocoons are first boiled and then reeled in this country is kept

inconveniently hot. It is not necessary to reel silk under this disadvantage. In fact, silk fibre kept too long in hot water loses in strength and elasticity. In filatures a steam-pipe issuing from a boiler is connected with every basin. With the help of a tap each reeler can raise the temperature of the basin to boiling point for boiling the cocoons, and then he can bale out some of this boiling water, add cold water to the basin, and then go on with working the boiled cocoons with a bundle of sticks to which the ends of the cocoons get attached, and finally with the reeling. But this is not altogether a convenient arrangement. A system which prevails in Italy seems to be adapted for this country also. In that country cocoons are boiled in a separate cauldron in water kept at the boiling temperature, *i.e.*, 100°C. They are kept in this cauldron for 5 to 10 minutes according to the quality of the cocoons, and immediately after distributed among the reelers. The water in the basin is kept at a temperature of about 40° C, which is therefore easily handled by the reeler. In addition to this advantage, the silk reeled in this way is found to possess greater strength and elasticity. Cocoons can be arranged in small wire baskets; these put in a large wire box; this box covered over with a wire lid; and the whole introduced into a vat of boiling water, and taken out after 5, 7 or 10 minutes, according to the quality of the cocoons. The box can then be placed on a wheelbarrow and the little baskets of cocoons distributed among the reelers, sitting on either side of a passage. Before these cocoons are reeled off another box of boiled cocoons may be similarly distributed, and reeling may thus go on uninterruptedly. These boiled cocoons put in the water of the basin furnished with a tepid water tap are likely to keep the temperature of the basin up at 40°C, or over this, at all seasons of the year, thus doing away with the necessity of fuel for heating the basin. The Italian system of boiling cocoons and getting them ready for reeling in tepid water may thus result in three advantages if it is introduced into this country. (1) No separate arrangement will be necessary to heat the water in the basin. (2) The reeler will not have to handle water inconveniently hot. (3) The silk reeled off will be better in quality.

206. (B) The water in which cocoons are boiled and then got ready for reeling should, if possible, be rain water. The rain water may be collected from the roof of the factory into a metallic tank, and distributed for use. In many places the proportion of lime in tank or well water is so great that its use results in the partial loss of elasticity of the silk fibre. Mixing with the water used a little pulp made by pounding chrysalides makes the cocoons to work off very freely. The chrysalides which accumulate in the basins can be used for making this pulp or paste. The pounding should be made so fine that the pulp may get evenly mixed up with the water of the basins.

207. *The Jette-bou.*—(C) It has been already said that it is after long practice that one is able to throw the end of a cocoon to join it on to other fibres when they are being reeled off quickly, and neatly. It is possible, however, to reel thread with little or no practice with the help of a mechanical arrangement called the *jette-bou*. A *jette-bou* is used in place of one of the porcelain discs or eyes. Reeling of silk is so easily accomplished with the help of *jette-bous* that in place of two porcelain discs six *jette-bous* are used to every basin. In other words, a reeler can, with this mechanism, turn out 6 skeins each time, or 12 skeins per day, instead of 2 skeins at a time, or 4 skeins per day. When *jette-bous* are employed, the basin should not be circular, but oval or oblong in shape (Fig. 30). A *jette-bou* is composed of the following parts:—A, a metal cap; B, a screw fixed on A; C, a tube coming vertically down from underneath A. The fibres from the cocoons pass through this tube and come out of the hole D before going on to the reel. The tube C is lined within with agate or glass. Owing to the presence of this lining, the tube C does not get worn out in time by friction with silk fibres. E, an iron tube which works freely round the tube C, and is not therefore constructed in one piece with A. This tube goes round C, and is kept in its place by a flange below the cap. The lower end of the tube E is serrated. Half an inch above this lower end a brass disc is soldered on to the tube. There are four notches in this disc to which the

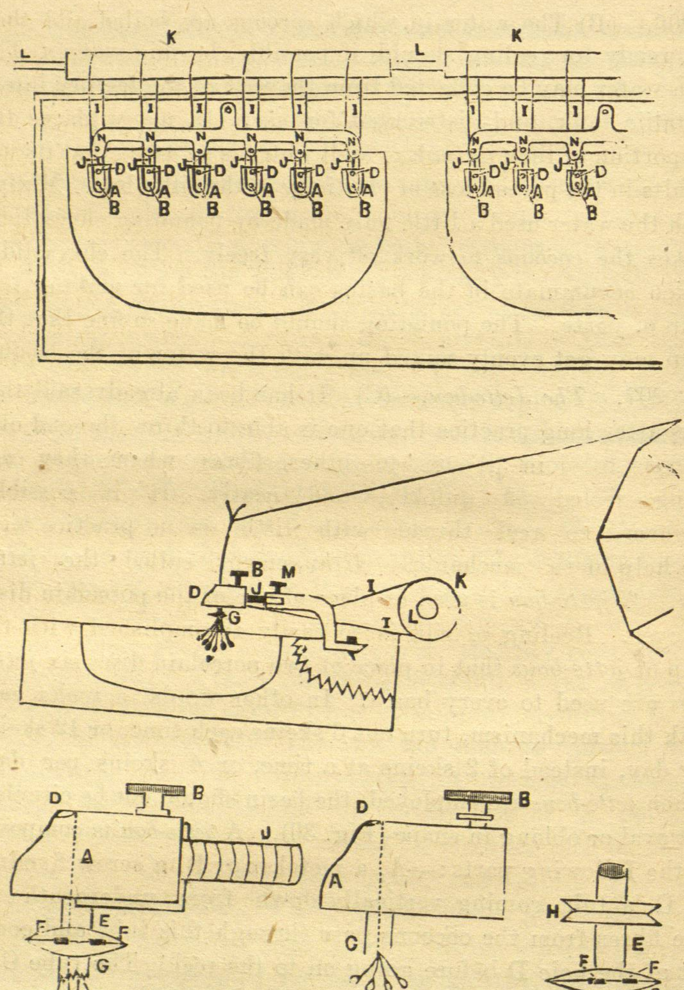


FIG. 30.—The Jette-bou.

ends of cocoons get caught up at the time of reeling. The notches are indicated by the letter F and the disc by the letter G. About one inch above the disc attached to the tube E is the brass pulley H also soldered on to the tube. Round this pulley works a string, which makes the tube E to spin round the tube C. Each *jette-bou* is worked by one endless string. These strings are represented by the letter I. It has been said that the tube E is kept in its place underneath the cap by a flange. This flange is indicated by the letter J. A part of this flange going on either side of the pulley H, which rests on the flange, the tube E remains *in situ*. The flange in its turn is kept in place by the screw B. It can be easily made out from the different portions of Fig. 30 how the *jette-bous* rest above the basins, jutting out with the help of the flanges just described. The strings mentioned above revolve in connection with the brass cylinders indicated by K, which in their turn revolve with the revolution of the reel which works in gear with the rod L. When this rod revolves the cylinders (K) revolve also, and with them the strings (I) which work the *jette-bous*. In course of time these strings become loose, when they are not able to work the pulley (H). When this is the case the screw M should be loosened, the flange J moved forward so as to make the string work tight round the pulley H, and the screw M tightened again. The hole in the flange J indicated by the letter N is meant to admit the screw B, which keeps A and J firmly adhering together. When reeling has to be done with the help of *jette-bous*, a number of fibres or ends of cocoons are to be taken up through the tube C up the hole D and on to the reel. A similar number of fibres from other cocoons are to be taken up through the tube C of the adjacent *jette-bou*, and the two sets of fibres made to cross. The croisures can be kept separate by means of two bars, exactly after the Bengal method. It may now be asked, " What is the use of employing such a complicated piece of machinery in place of a porcelain eye? " The use of the *jette-bou* is attended with the saving of skilled labour, inasmuch as the end of a cocoon does not need to be joined on to the fibres which are being reeled after several attempts, but it requires merely to be quietly brough to the disc G, when it is caught up by a notch (F), cut with the teeth at the end of the tube C, and sucked in by the other fibres, and joined on automatically with them. The reeler simply sees that the number of cocoons that should spin under each *jette-bou* is actually present. When a cocoon is worked off, and its chrysalis sinks in the basin, the reeler brings the end of another cocoon in contact with the disc G. The joining on of the fibre takes place automatically. The ease with which new cocoons are added on with the help of *jette-bous* makes it possible for one reeler to work off six skeins of silk at a time. Another advantage in using *jette-bous* consists in the fact that an untrained labourer can, after practising reeling of silk only for a day or two, turn out silk of good quality with the help of this machine. European silk factors find the management of labour very difficult, as the labourers require to be trained men under the existing system of reeling. If they could do without employing skilled labour in filatures, they would find the management of the factories easier. *Jette-bous* are not easy to construct. Even if they could be contructed, patent rights would be in the way. They should therefore be imported. Messrs. Berthaud and Son of Lyons can supply *jette-bous* of simple construction. To adapt the *jette-bou* to the Bengal system of reeling should not be difficult. As this piece of machine has been substituted for the porcelain eye or perforated disc, both in the French and Italian systems, so should it be possible to substitute this for the eye or disc in the Bengal system also. The purchase of *jette-bous* will, of course, cost an extra outlay of money, but this is sure to be made up by the advantages accruing from their use.

208. *Reeling of Tusser Cocoons.*—It is more difficult to reel tusser cocoons than mulberry cocoons. In Birbhum, Bankura, and Raniganj the people use ashes got by burning plantain leaves for boiling the cocoons with in water for two or three hours together. The boiled cocoons are left to ferment for some hours before the fibre is gathered on to *látáis*. Some European factories for reeling tusser cocoons have now been

established in Bengal. In these imported soda or potash, oil and sugar are used, or simply soda or potash. One and a half seers of pure carbonate of potash are mixed with about a maund of water, the peduncles of the tusser cocoons are cut off, and the cocoons are weighted with stone and sunk in the water to which the potash has been added, tied up loosely with a cloth. The cocoons are boiled in this water for half an hour, and then for a few minutes in water to which a little glycerine has been added. The reeling then goes on in the same way as the reeling of mulberry cocoons. The addition of glycerine makes it unnecessary to have the cocoons spinning in basins of water, as glycerine helps to keep the cocoons moist throughout the operation. Tusser cocoons can be reeled by a much simpler process. A quantity of chrysalides of the tusser or the mulberry silkworm is to be made into fine powder or paste, and mixed up with the water in which the tusser cocoons are to be boiled. The chrysalides should weigh about half the dry cocoons to be treated. The paste is to be mixed up with the cocoons, which are to be tied up in a cloth, weighted and plunged in water. One hour's boiling will be found sufficient. The boiled cocoons should be left to ferment for 12 hours, and reeling can then go on, the cocoons being allowed to spin in basins of hot water in the same way as mulberry cocoons are made to spin. Whatever process may be adopted for reeling tusser cocoons, the thread should be plunged in a warm acid solution, then washed in boiling water to which soap or *sáji* (crude carbonate of soda) has been added, and finally rinsed in clean water, wrung and dried, and then baled for exportation. Glycerine, oil or chrysalis-paste, remaining adhering on tusser thread, fermentation is likely to set in and weaken the fibre in the course of transit. The object of treating the thread in acid solution is to correct the effect of lime (of which there is naturally an excess in tusser fibre) and of the alkali used for reeling. The lime and the alkali lessen the brilliance and elasticity of tusser. The acid also neutralizes the oleaginous substances that get adherent to the thread in the course of reeling. Ten seers of tamarind with seed are sufficient for preparing an acid vat for treating a maund of tusser thread. The tamarind should be mixed up with water, made into a mash, and strained with a cloth. The subsequent boiling of the tusser thread in soap or *sáji* water may be omitted if desired, but the final rinsing in boiling hot water must be done after treating the thread with the acid solution.

209. *Improvements suggested in the reeling of Tusser.*—In Bengal a number of tusser-reeling factories have been established in the district of Murshidabad. There are no factories in those districts where tusser cocoons are raised. The tusser silk industry will be greatly benefited by the establishment of factories in Manbhum and other districts where the tusser worms are reared. In the village of Pakhuria, in Manbhum, the Rev. A. Campbell has commenced teaching the reeling of tusser to Sonthal youths. This may pave the way to the establishment of a reeling factory in Manbhum. Sonthals work much cheaper than other classes of labourers, while the transport of a bulky article like tusser cocoons from one district to another is at present found very expensive.

The best method of reeling tusser cocoons is yet to be discovered. The experiments of M. Gautier, the Rev. A. Campbell, Mr. Otto Anz and others have made the way very clear; but the goal cannot be said to have been reached as yet. The use of vegetable and animal pepsine, recommended for the Eri cocoons, seems to be fraught with important consequences, and persons interested in the development of the tusser-reeling industry may give this method a fair trial. Natural fermentation with chrysalis-paste is also a very easy way of getting the gum of tusser cocoons dispersed. The following two processes are also recommended for trial:—(1) Let 20 maunds of water be boiled in a metallic tank. When the water begins to boil, add to it 15 seers of *babul* gum. When this has mixed up with the water, add to it fine paste from 13 seers of tamarind in seed, then 10 seers of rock-salt, and last of all 10 seers of saltpetre. When the water is still in a boiling condition, a basket of tusser cocoons, divested of peduncles, measuring about 4 feet × 4 feet × 3 feet, is to be lowered into the water, and left boiling for 2½ hours. The basket is then to be left in steam for another half an hour, dried afterwards, and reeled off in the dry state. (2) Three seers of tamarind seed are to be battered and divested of their outer coats, and the kernels made into a fine powder with a *dhenki*. This powder is to be added to 20 maunds of warm and afterwards boiling water. Four seers of castor-oil and four seers of brown sugar are then to be added, and the basket of cocoons lowered into this boiling vat, and kept in it for 2½ hours, and steamed for half an hour, and afterwards reeled as before.

One man can reel about 260 tusser cocoons *per diem*, and obtain 18 to 20 *tolás* of silk. Four cocoons reeled together make 40 *denier* silk, and 6 cocoons, 60 *denier* silk. The basket mentioned in the preceding paragraph would hold about 60 *káhans* (60 × 1,280) of tusser cocoons, and would boil enough for 300 reelers for one day.

210. "*Short Skeins*," or *Native-reeled Mulberry Silk.*—In the district of Malda, the annual outturn of short skeins or *khamru* silk from English Bazar, *Jot*, Bholahat and a few other less important localities is about 2,000 maunds. Native-reeled silk is also produced in almost all the villages in Birbhum where silkworms are reared. In the other silk districts, also, there is some cottage reeling done, of which it is difficult to form an estimate as to quantity. The native-reeled silk of Birbhum is inferior to that produced in Malda. The weft silk of Malda is of still better quality than the warp silk. At Mirzapur and other villages in Murshidabad, where silks of a superior quality are woven, the native-reeled silk of Malda is almost exclusively employed. At Bashoa-Bishnupur and other villages near Kandi (also in the district of Murshidabad), the native-reeled silk of Birbhum is chiefly employed. It is not to be supposed that the native-reeled silk is chiefly consumed in the looms of Murshidabad. In Bankura (at Vishnupur and other villages) and in Midnapore (at Chandrakona and other villages) a great deal of native-reeled silk is used. In fact, Bengal consumes only a small proportion of the raw silk she produces. Most of the native-reeled silk goes to Benares, Nagpur, Karachi, Mysore and other

important silk manufacturing localities, travelling merchants from these places coming to Bengal to buy the raw material. In Bengal, wherever silk-weaving is done, the "short skein" is the raw material that is used almost exclusively. The inferior quality of raw silk imported from China is also used in native looms. For the last few years the native silk-reeling industry has been steadily improving. At times the price of this inferior silk goes up higher than that of the superior raw silk turned out from European factories. This absurdity can be explained only by the ignorance of native silk merchants regarding the state of the European silk market. The silk-reeling industry of Bengal suffers considerably by the absurd procedure of native silk merchants. At one season when the market price in Europe for the superior filature silk of Bengal was Rs. 14 per seer, these native silk merchants were buying the inferior *khamru* silk for Rs. 15-8 per seer. Under such circumstances, Native silk reelers began buying cocoons at a higher price than European silk factors. The latter saw that they could not make any profit buying cocoons at Rs. 40 or Rs. 41 per maund. Cocoon-rearers in Malda also made up their minds not to sell their crops for less than Rs. 40 or Rs. 41 per maund. The factories were closed for some time. The native silk-reeling went on briskly for a few days, while most of the cocoons remained locked up in the houses of silkworm-rearers. In a month the price of the *khamru* silk came down from Rs. 15-8 to Rs. 12-8, and only those few silkworm-rearers who had succeeded in selling their crop for Rs. 40 or Rs. 41 per maund made a profit. Most of the cocoon-rearers who had kept their crop locked up for two months got more heavily involved in debt to the money-lenders, and finally sold their April and May crops of cocoons at the low price prevailing during the rainy season. Native silk merchants and silk reelers should accept as just the prices at which European factors buy cocoons or sell their silk, if such disappointments are to be avoided. European silk factors make exact calculation as to the price of cocoons they ought to pay after consulting the state of the European market at the time. Native silk merchants and silk reelers should simply follow them in this matter. If they do not, they may make an accidental profit but they are more likely to lose. Buying cocoons at the same price at which European factors buy them, native silk reelers can make sure of their profit, as for various reasons *khamru* silk is worked cheaper than the filature-reeled silk:—(1) The yield of *khamru* silk is larger. (2) A spinner can turn out three times as much *khamru* silk as filature silk. (3) As 6 skeins of *khamru* silk are turned out at a time instead of 2, the number of winders required is also less in the case of the *khamru* silk. (4) The establishment charges of a European factory are considerably larger. For the above reasons, the manufacture of *khamru* silk proves more profitable to the native reeler than that of filature silk, notwithstanding the higher price which is or ought to be obtained for the latter. From a maund of green cocoons 2½ to 3½ seers of *khamru* silk is obtained, the outturn of filature-reeled silk being about half a seer less in either case. The cost in reeling off a maund of green cocoons into *khamru* silk is Rs. 3-8 to Rs. 4. The cost of reeling a maund of poor cocoons is the same as that of reeling a maund of good cocoons, though the produce in the two cases differs a great deal in value. To the European factor a seer of silk costs about Rs. 2 in reeling. A maund of green cocoons yields 2 to 3 seers of "waste silk" as a bye-product to the native reeler. These 2 to 3 seers of "waste" sell for Rs. 3 to Rs. 3-8. The cost of reeling native silk is, therefore, sometimes defrayed by the sale of the bye-product, and any excess in the sale price of the silk turned out above the purchase price of cocoons yields a net profit. If a maund of green cocoons has to be bought for Rs. 40, that is if the cocoons are very superior, three seers at least of *khamru* silk can be expected as the produce. But the average price of superior cocoons should be taken as Rs. 30 per maund. The three seers of *khamru* silk can be sold at Rs. 30 to Rs. 46 according to the fluctuation of the market. The weft silk, again, can be sold for Re. 1 to Re. 1-8 more per seer. Native silk-reelers usually pay higher wages to their spinners and winders than European silk factors.

In Malda the spinner in a native reeling establishment gets Rs. 6 to Rs. 10, and the winder from Rs. 4 to Rs. 6 per month. European factors, however, have to advance money in engaging spinners and winders. It is for this reason they are able to secure spinners for Rs. 5 to Rs. 6 a month, and winders for Rs. 3 to Rs. 4. The spinner and winder in a Native silk-reeling establishment work much harder than in a European filature. In the hot season they begin work at 4 in the morning, and go on until 1 P.M. In the cold season they work from 6 A.M. to midday, and again from 1-30 P.M. till 4 P.M. In European factories regular work goes on only for eight hours in the day. The weft *khamru* silk is reeled out of 8 seers of green cocoons (about 3 seers of dry cocoons) by each spinner *per diem*. If he has to make warp silk, he has to reel off 10 seers of green cocoons (about 3¼ seers of dry cocoons) before he gets leave for the day. *Khamru* silk is sold by 82½ *tolá* weight. Filature silk is sold by 72¾ *tolá* weight. With 1 maund of *khamru* silk are obtained 25 to 30 seers of "waste." This waste is not clean like the filature waste, but full of chrysalides. In filatures, the quality of cocoons is fairly judged from the "waste" they produce. If on reeling 11 *káhans* of cocoons 1 seer of silk is obtained in a filature, *i.e.*, if the cocoons are tip-top in quality, 11 seers of waste are expected with a maund of this silk. If the cocoons are poor, and they go 20 *káhans* to the seer, 20 seers of waste are expected with a maund of this silk. The filature waste which is clean sells for Rs. 80 to Rs. 100 a maund in the Calcutta market, while the *khamru* "waste" sells from Rs. 38 to Rs. 60 per maund. In filatures each spinner makes 4 skeins of silk per day, which weigh from 3 to 4 *chitaks*. In *khamru*-reeling establishments each spinner turns out 12 skeins per day. If these are weft silk, they weigh 8 to 9 *chitaks*. If they are warp silk, they weigh 10 to 14 *chitaks*. The comparison here instituted will show that, on the whole, it is more profitable for the native reeler to reel coarse *khamru* silk. Bengal *khamru* silk is not exported to Europe; but coarse silk is exported to Europe from China and Japan; and it is advisable to export *khamru* silk also to

Europe. But it will scarcely find a market unless it is re-wound before export. In the manufacture of the *khamru* silk thread, the winder turns the reel very fast. When a thread happens to break, he makes the re-attachment anyhow without putting a knot, and the winding of the reel goes on as before after a moment's interruption. Such being the case, it costs a great deal unwinding the *khamru* silk from the skeins into bobbins. The cost of labour in Europe is so great, that *khamru* silk will fetch very little price unless it is exported in a re-winded state. A great deal more of *khamru* silk is produced in Bengal than filature silk. The competition between European factors and Native reelers is therefore very keen. The best way for European factors to avoid the evil resulting from this competition is to recognize the *khamru* silk as an article of export, to buy up large quantities of it, to re-wind it, and send it to the European market. The effect of such a procedure will be twofold:—(1) to give the native silk-reeling industry a still greater impetus, and (2) to combine it with European enterprise. That a very wide field is likely to be opened out in Europe for the coarse Bengal silk is the opinion of some of the best manufacturers of England, France and Italy. No time should be lost in taking advantage of an enterprise that is likely to develop export trade in a new direction, while giving an impetus to an already flourishing native industry. For such manufacturing purposes (*e.g.*, for manufacturing shoe-maker's twine) where coarse sizes are preferable to fine sizes, the native-reeled silk, if exported re-wound, would be preferred to the more expensive filature-reeled silk.

211. We may conclude this chapter by giving an estimate of cost and outturn of a filature of 100 basins conducted on the Bengal (European) system:—

	Rs.	A.	P.
(1) Purchase of cocoons, at 3½ *káhans* per basin per day, for 250 working days (100 × 3½ × 250 = 87,500 *káhans*), at 11 annas a *káhan*	60,156	4	0
(2) One hundred reelers, employed for 250 days, on Rs. 6 per month ...	5,000	0	0

		Rs.	A.	P.
(3) One hundred winders, employed for 250 days, on Rs. 4 per month ...		3,333	5	3
(4) Two coolies for pumping water, for 250 days, at Rs. 5 per month ...		83	5	3
(5) Coal, 35 maunds for each maund of silk turned out, and 2½ maunds for the stove-room for each maund of silk turned out (say, 136½ maunds out of 87,500 *káhans* of cocoons), *i.e.*, 5,126¼ maunds, at Rs. 40 per 100 maunds		2,050	12	0
(6) Fuel for ovening, etc., 500 maunds, at Rs. 25 per 100 maunds ...		125	0	0
(7) Repair of filature		300	0	0
(8) Establishment charges :—	Rs.			
European Assistant, including commission ...	4,000			
Gumashta	480			
Clerk	240			
Godown-keeper (also clerk)	180			
Hazir-nabish (roll-caller) ...	84			
Chaukidar	72			
Two barkandazes or peons ...	120			
Three filature sardars or foremen	180			
Oven sardar	72			
Engine lascar	72			
Carpenter	120			
Sweeper	72			
		5,692	0	0
(9) Contingent expenses		1,200	5	6
Total expenditure ...		77,941	0	0

	Rs.	A.	P.
Outturn—			
136½ maunds of 10—12 *denier* silk, at Rs. 800 per maund	1,09,200	0	0
45½ maunds of *chasam* or tape-waste, at Rs. 100 per maund	4,550	0	0
9 maunds of *gudar* or coarse *chasam*, at Rs. 40 per maund	360	0	0
34 maunds of *topá* or unreelable portions of cocoons, at Rs. 7 per maund	238	0	0
Total outturn ...	1,14,348	0	0
Deduct expenses ...	77,941	0	0
Net profit ...	36,407	0	0

According to the above calculation of expenditure, each seer of cocoons (and a filature seer is only 72¾ *tolás*) costs over Rs. 14; and if the price realized is only Rs. 12 or Rs. 13 per seer, as sometimes happens, instead of a net profit, a net loss would be the result.

CHAPTER III.

WINDING, WARPING, AND WEAVING.

212. *Unwinding*.—Native weavers, as a rule, employ *khamru* silk in their looms. It is only rarely that they employ European filature silk, or "Latin" silk as they call it, for turning out some very superior fabric. In weaving "Pákwán" (made out of twisted thread) silks, the weaver first unwinds the skeins, that is, transfers the thread from the skeins to a number of *látáis;* he then gets this raw silk twisted, and finally gets it warped before he commences weaving. In weaving "Kham" silks (those made out of raw or untwisted silk), the weaver gets the thread unwound and gathered on to

látáis, and then warped before commencing reeling. If the thread is bleached and dyed before it is used for weaving, the thread is bleached and dyed after it has been warped. The thread for the weft is gathered on to *látáis* from the skeins, two or three fibres from the skeins of raw silk going to form a weft-thread. The weft-thread is taken out of *látáis* and bleached and dyed if necessary. In other words, whether the raw silk is used in a twisted or untwisted condition, whether it is bleached or not, whether it is dyed or not, it must be unwound before it is used. The unwinding is done with two objects:—(1) to gather the thread of the same thickness or " size " in the same *látáis* and (2) to get one uninterrupted thread in each *látái*. The skein of raw silk is loosened out and put round a frail bamboo wheel called " *polti* " or " *chorki*." The end of the skein is attached to a *látái*, and the thread transferred to the *látái* by keeping it turning with the right hand, while the thread is made to pass between the thumb and the index finger of the left hand. The stick passing through the axle of the "*polti* " being loosely planted in a hole in the ground or in the hollow of a thick piece of bamboo, the turning of the *látái* with the right hand makes the thread come out unwound from the skein. The thread passing through the fingers of the operator, he can judge of its thickness. Thread of the same thickness is wound on to one *látái*, so that three or four *látáis* are sometimes employed for unwinding one skein of native-reeled silk. In unwinding the thread, the clue is lost from time to time. To get back the clue or end, some waste takes place. European filature-reeled silk is easily unwound, as it is fairly even in thickness throughout, and a whole skein can be gathered on to one *látái*. One *tolá* or half a *tolá* of silk per seer is wasted in unwinding filature silk, and half a *chitak* to one *chitak* is wasted per seer in unwinding the *khamru* silk. It costs about annas 8 per seer to get raw silk unwound. Women are usually employed in this work.

213. *Throwsting or Twisting.*—The raw silk gathered on to *látáis* may be used for warping in untwisted condition for

manufacturing *kham* silks, or silks of poor quality. For manufacturing superior silks twisted thread is employed. Superior silks are therefore styled "*pákwán*" (=twisted). The native process of twisting is extremely simple and inexpensive. In other words, the total cost of the tools and appliances used in twisting silk thread is less than one rupee. But to get a seer of silk thread twisted by this process costs about two rupees. In Europe labourers are paid nearly ten times as much as in this country, and yet getting a seer of raw silk twisted in Europe costs only about eight annas. The machinery used in Europe for twisting silk thread is not so complicated that it cannot be constructed even in country places in India. The chief obstacle to the employment of the Bengal raw silk in Europe is the greater cost it entails in unwinding. The Bengal raw silk should be re-wound and twisted in this country before export. Re-wound raw silk has begun to be exported by certain firms. If it is exported as thrown-silk, the difference of Rs. 6 or 7 per seer between European and Bengal silk is likely to disappear. Indeed, one of the principal ways of ameliorating the export trade in Indian raw silk would be the recognition of *Organzine* and *Trame* as the staples of export instead of raw silk. Doubt may be reasonably entertained with regard to the advisability of introducing the complicated power-looms of Europe into this country under existing conditions ; but there is no doubt it is high time that the comparatively simple machinery required for throwing silk should be introduced into this country. European methods, indeed, should be introduced into this country as a rule. China and Japan have been able to develop their silk industry considerably by the adoption of European improvements. That the old methods are the best for India alone can never be accepted as a sound theory. With regard to the Japanese enterprise, one fact only may be pointed out as quite conclusive: we are now buying Japan-made handkerchiefs and other silk articles even at Berhampore. These are quite European in style and finish.

The Native Process of Twisting.—In twisting silk by the native process, the *látáis* are planted loosely in holes in the floor. The threads are passed through an iron guide firmly planted in the floor, and are carried up in front of the operator through a U-shaped piece of cane attached to a bamboo lath, and then through the first glass *bangels* of the upper series of five or six *thháks* or bamboo erections, back through the first glass *bangels* of the lower series of the same *thháks* and the second U-shaped cane in front of the operator, when the threads are snapped at the iron guide, and a *tákur* tied at each end, the two ends being then made to hang vertically at equal heights from the floor. Another length of thread is then taken exactly in the same way from the *látáis,* passed through the guide, the third U-shaped cane, the second glass *bangels* of the upper rows of the *thháks,* back through the second glass *bangels* of the lower rows of the *thháks* and the fourth U-shaped piece of cane, two *tákurs* being again tied at the two ends in front of the operator. In this way eight lengths of threads with 16 *tákurs* attached to their ends remain hanging in front of the operator. From the U-shaped pieces of cane to the last *thhák* being about 20 cubits, 320 cubits of thread are twisted at the same time by each operator. The distance between the U-shaped canes and the last *thhák* is sometimes 40 cubits, when double the length of thread is twisted at the same time. The *tákurs* are simply slender pins of bamboo with mud weights attached to their bottom, which help to keep the threads straight while the twisting is going on. The operator simply keeps rubbing the pins of the *tákurs* successively between the palms of his hands, so as to make them spin fast and uninterruptedly, which serves to twist the threads. When the *tákurs* are only 9 inches from the U-shaped canes, by the shortening of the threads by 9 inches as the result of twisting, the operator considers the twisting as done. The eight pieces of twisted thread are then gathered on to a *látái* as one continuous piece by knotting them together. More thread is then twisted exactly in the same way. Two to three lengths of raw silk are twisted together. In other words, the pieces of thread passing through the same *bangels,* etc., are taken from two to three *látáis* at the same time, and not from one *látái.*

214. *Warping.*—Warp-threads for 5, 10 and sometimes 20 pieces are rolled round the warp-beam before weaving is done. Before arranging the loom, therefore, it is necessary to get the warp (50 to 80 yards long) ready. The bleaching and dyeing are done in the warp. The thread for the weft is bleached and dyed in small skeins as they are taken out of *látáis*. In warping the thread from the *látái* is laid along bamboo laths called *joás* fixed in a row in the ground. The *látái* is held with the right hand, and with the left a stick with a glass ring at the end. The thread is passed through this ring and laid alternately against the two sides of the laths in a neat manner. When the proper number of threads have been laid against the bamboo laths, they are drawn out of the laths, tape bands being substituted for the laths. The warping being finished, bleaching and dyeing are done, or the unbleached warp used for feeding the loom. When the loom is set, the tape hands are taken away, and in their place thin laths of bamboo called *joá kathis* are substituted, and the warp tied to and wrapped round the off-beam or the warp-beam. The use of the bamboo laths has two objects: (1) to keep the threads of different colours separate, and (2) to allow the *baws* or " healds " to work without interruption. The introduction of these laths at regular intervals makes the different sets of threads required to come up or go down with the healds do so in a neat manner, forming a shed for the introduction of the shuttle. In weaving check pieces 200 of these laths are used for a 50-yard warp. The threads of the warp are passed through the dentations of the " reed " and tied to the " cloth beam." As the weaving proceeds the cloth is wrapped round this beam, and the warp set free from time to time from the other beam.

215. *Charging of Spools.*—The skeins of weft-thread are transferred to little pieces of reed called *nalis* (spools) with the help of a wheel. These, with a small quantity of weft-threads charged on them, are introduced into shuttles. In weaving thin muslins only the weft comprises a single thread; in other cases two threads gathered from two *látáis*. The two weft-threads in this country are not twisted together, but in Europe a certain amount of twisting is given to the weft-threads also.

As the warp is used either bleached or unbleached, dyed or undyed, so is the weft.

216. *Weaving.*—It is impossible to do weaving with the help of a book. It is entirely a matter of practice. To form an idea of a loom by reading an account of it is not difficult, but it is a different thing altogether to be able to weave a piece of silk. Looms for weaving silks are exactly like looms for weaving cotton cloths. The looms for making the figured silks of Baluchar (Murshidabad), however, are of a special kind. They are extremely complex in construction, so much so that there is at present only one weaver in the district of Murshidabad who understands the principle of the construction of these looms, and who is able to set them. One reason for the backward state of the silk-weaving industry of Baluchar (where the figured silks are manufactured) is that there have been, for several years, only one or two men who have been able to set these looms. The only man now living who understands the construction of these looms, *viz.*, Dubraj, is an old man of about 80. The looms Dubraj constructs for himself produce excellent shawls, sashes, table-covers, *saris*, &c., which are eagerly bought up by the rich people of Murshidabad. The figured *saris* ordinarily made at Baluchar are not neat, and they are no longer in fashion. The Baluchar *saris* and other kinds of figured silk may again rise in public esteem if a number of weavers get to learn from Dubraj the principles of construction of looms for bringing out any desired patterns. The looms we ordinarily see are worked with " healds " (for separating the different sets of warp-threads) and shuttles (for introducing the weft). In the *nakshá* loom, that is loom for weaving figured silks, in addition to healds and shuttles there are used (1) a series of cords connected with loops with the warp for separating the different lots of warp-thread, and (2) spools for introducing the weft for bringing out the figures. In an ordinary loom one operator does the whole work. In the *nakshá* loom one man works the healds with the treadle, introduces the weft first with the shuttle and then with the spools, and finally presses the web close with the reed, while another person handles the cords one after another, so as to bring the proper threads of the warp up, to enable the other man to introduce the spools in the right places. The arrangement of the

cords is extremely complicated. It is by working these one after another and introducing the weft with the spools that the figures come out. Any attempt to explain this complicated arrangement will be futile, and it is recognized as a secret which Dubraj alone can unravel.

217. *Use of Silk Fabrics.*—The high class silks turned out from the looms of Mirzapur and other neighbouring villages in the district of Murshidabad are almost equal to European silks in appearance. European silks, as a rule, never prove lasting. After washing they usually become quite shabby. Native silks may appear wanting in quality and dear when they are first bought, but with their use the conviction dawns that they are much cheaper in the long run than European silks. The stability and growth of the native silk-weaving industry depends, not so much on the introduction of European machinery or other improvements, as upon the appreciation by the natives of India of the intrinsic merit of native silks. The wages of labourers in this country are so small that it may be reasonably questioned whether the introduction of labour-saving machinery will do much good to the silk-weaving industry. The decision of this question will depend on actual experiments. The fact, however, should be borne in mind that the introduction of power-looms in Japan has given a most remarkable impetus to the silk-weaving industry of that country. The import of European silks into Japan has practically ceased, while Japanese silks have begun to be exported even to European countries. The use of European silks has become so general in India that their manufacture in this country seems desirable. The silks manufactured in a factory at Narkoldanga, near Calcutta. and also in Bombay, in imitation of European silks, by the use of European machinery, have come to be highly appreciated. These, however, it should be borne in mind, are devoid of those qualities for which the Murshidabad, Birbhum, and Assam silks, tussers, and Endi cloths are valued. The European and Native methods have both their excellences and their defects, and they are both worth encouraging on their own lines.

CHAPTER IV.

BLEACHING AND DYEING (NATIVE PROCESSES).

218. *Fourteen Native Colours.*—In Bengal the following 14 colours are recognized in the dyeing of the silk:—(1) Deep blue or indigo-black; (2) light blue or grey; (3) red and light red; (4) yellow; (5) orange; (6) green; (7) purple; (8) chocolate colour. Besides these 8, 6 other colours are brought out by the use of one coloured thread for the weft and a different coloured thread for the warp. These are—(9) *Pitambari* colour (red warp and orange weft); (10) *Sonáli* (gold) colour (green warp and orange weft); (11) *Hirámankanthi* colour (green warp and red weft); (12) *Mayurkanthi* colour (red warp and green weft); (13) *Dhupchháya* colour (red warp and blue weft): and (14) *Ashmáni* colour (blue warp and red weft).

219. *Bleaching.*—The colour of the raw Bengal silk, both of European and Native manufactures, is yellow, that is like that of the cocoons out of which it is made. This, however, is not a permanent colour, and it has to be removed by bleaching it white before it is dyed. The silk of the annual *Barapalu* cocoons is usually white, but this also has to be subjected to the bleaching process before it can be dyed. In bleaching a seer of silk: (*a*) 1 pow (½ lb.) of *sáji* (crude carbonate of soda) is powdered and mixed up with 2½ seers of hot water, and the liquid strained through the same piece of cloth for a number of times, or (*b*) half a seer of ashes obtained by burning plantain leaves only is mixed up with 2½ seers of hot water, and the liquid strained as before, or (*c*) half a pow of *sáji* and one pow of the ashes are mixed up with the water and then strained as before. A piece of cloth is spread over a basket, and the water to which the powdered *sáji,* or ashes or a mixture of the two has been added is poured on to the cloth, and gathered in a vessel underneath. This liquid is again poured into the basket and strained a second time. The straining is repeated until the liquid looks like oil. This liquid is mixed with about half a maund of water and boiled. Into this boiling water the seer

of silk is introduced, out of which it is taken when the bleaching is done, and washed in a tank of clean water. After the silk is dry it will be found on weighing that it has lost about a quarter of its weight by the bleaching operation. If a piece of white (or undyed) silk weighs 21 *tolás*, it should be inferred that 21 + 7 = 28 *tolás* of unbleached silk thread have been used in weaving it.

220. *Cost of Bleaching.*—

	A.	P.
One pow of *sáji*	0	6
Fuel	1	3
Labour	1	3
Total cost of bleaching one seer of silk ...	3	0

A much greater quantity of silk can be bleached at the same time and the same man do other work besides bleaching a seer of silk. It is only a portion of a day's wages of a man that has, therefore, been calculated. If a seer of raw silk is bought for Rs. 15, it will have cost Rs. 15-3 when it is bleached, but its weight will stand at only ¾ seer. If a little more than ¾ seer is obtained, this excess vanishes after it has been unwound and gathered into *látáis*. In unwinding native-reeled silk as much as half a *chitak* is lost. Good filature silk stands at about 65 *tolás* after bleaching and unwinding, as the unwinding produces only a *tolá* of waste.

221. *Mordanting with Alum.*—As a rule bleached silk requires to be mordanted before a dye can be permanently fixed into it. To mordant a *seer* of bleached silk 10 *tolás* of alum are used. This quantity of alum is mixed up with about 10 seers of water and boiled. The silk is put into the alum water when it is still hot, and turned about in the solution for half an hour to get the fibre mordanted evenly. It is then wrung out and put in the dye in a moist state. This preparatory mordanting is not required for dyeing silk with lac, *anatto*, and indigo.

222. *Cost of Mordanting.*—

	A.	P.
Ten *tolás* of alum	1	0
Fuel	0	6
Labour	0	6
Total cost of mordanting a seer of silk ...	2	0

223. *Black, Blue, and Grey.*—There is no proper black dye in use in Bengal. Deep blue or deep chocolate colour goes by the name of black. The chocolate colour will be described in its proper place. To dye silk deep blue or black the bleached silk is put in the indigo vat, wrung out, dried and again put in the indigo vat. After four to six such operations the fibre looks almost black. Of all the dye-stuffs used in Bengal, indigo is the most expensive. In the Calcutta market a seer of indigo costs Rs. 6 or Rs. 7. Ten *tolás* of indigo are used for each dipping of a seer of bleached silk in the indigo vat. To dye the silk grey one dipping is sufficient. The silk weavers of Murshidabad can always manage to buy 10 *tolás* of indigo for annas 8, though the price of this article in Calcutta is much greater. If the silk is dipped six times in the indigo vat for dyeing it black, the cost comes to Rs. 4 per seer. To dye silk grey it costs Re. 1 per seer, inclusive of labour. To the indigo vat is added lime and ashes obtained by burning indigo refuse (*siti*), also *seed* of *Cassia Tora* (Chákandá). When these are not used, the colour obtained is not permanent. The froth or scum which rises on the surface should be blue, but underneath the surface it should be green. These two circumstances prove that the indigo is properly dissolved, and that the alkaline salts are united to the colouring atoms of aniline in indigo, which is a volatile alkali developed by the fixed alkali of the *siti*, and the *Cassia Tora*, or by the terreous alkali of the lime, and evaporated in a short time after the froth has been exposed to the air. In weaving figured silks, when it is intended to have the figures white on white ground, the weft-thread is dyed blue. This blue is not fast, no lime, *Cassia*

Tora seed, and ashes being used in its preparation. Such cloths get white in time by washing, the figures remaining white on white ground. It is not with any dishonest motive that weavers use this fugitive blue colour, but simply for the convenience of weaving the figures.

224. *Red and Pink.*—To get the exact shade of red on silk is considered by native weavers a very difficult thing. The reason for this is twofold. First, native weavers do not weigh their dye-stuffs, etc., nor keep exact time by the clock, nor measure the temperature of liquids with thermometers, but do everything by guess-work. Secondly, lac and *lodh (symplocos racemosa)* dust are both substances which are more or less adulterated, and it is impossible to get exact results simply by weighing. It requires experience to get the exact shade of red. The lac is first made into a coarse powder with a quern. It is then placed on some vessel, some water added to it, and it is rubbed with the palm of the hand against the vessel. While this rubbing goes on *sáji* is dusted over it. For each seer of lac 1¼ to 1½ *tolá* of *sáji* is used. Two to three times the quantity of raw silk to be dyed is the proportion of lac used. After the rubbing of the lac and the *sáji* is over, the paste is transferred to a piece of cloth spread inside a basket. The basket is placed on three pieces of bamboo over a trough (*gámlá*). Water is then poured over the paste in the basket, and the solution of the dye gathered in the trough below. About 30 seers of water is used when a seer of silk has to be dyed for getting all the colour of the paste into the trough. Boiling of the liquid goes on for about three hours. When the boiling is going on *lodh* dust is sprinkled over the liquid. The quantity of *lodh* used is the same as the quantity of *sáji* that has been already used for making the paste. To ascertain when the " bowl " of liquid is exactly ready, the following test is used. A drop of the boiling liquid is dropped into a vessel of plain water. If it sinks to the bottom of the vessel in the form of a ring, the " bowl " is ready. If it does not sink in this neat manner, but disperses in the water, it should be inferred that it requires more *sáji* to make it right. A

solution of *sáji* is then required to be added until the boiling liquid satisfies the test. If the drop of the liquid appears too dark (blackish), a little more *lodh* dust is dusted to make the " bowl " right. When the " bowl " is ready, the *gámlá* is taken down from the fire and kept covered up for a day. Next day it is again put on the fire, and as soon as boiling takes place, bleached (but not mordanted) silk is put in the liquid and stirred. When this stirring of the silk in the boiling liquid is going on tamarind water is added to it. The tamarind used for this purpose should not be quite fresh from the tree, nor very old. It should be a few months old. For a seer of silk, a seer of tamarind (inclusive of the weight of the seeds) is used. When the proper shade of colour has been obtained, a *chitak* of alum is put in the liquid, the silk stirred for a moment longer, taken out, wrung and dried. If alum is not used, the dyed silk requires to be " *lodhed* " before the dye is permanently fixed. To " *lodh* " a seer of the dyed silk, half a pow (¼ lb.) of turmeric is made into a paste and mixed up with half a pow of *lodh* dust, and the mixture boiled in about 15 seers of water. The dyed silk is put in this liquor and taken out, when the dyeing will be quite finished. If there is too much water in the " bowl," the colour obtained is pink. To get a seer of bleached silk dyed red at a dyeing establishment costs Rs. 2-8.

225. *Yellow.*—Four seers of sawdust of jack-wood. (*Artocarpus integrifolia*) and one seer of *bákásh* leaves (*Adhatoda vasica*) are boiled together in half a maund of water. The liquor is strained off and a seer of bleached and mordanted silk put in it, stirred well, taken out, wrung, and dried. This process is repeated three times more, when the yellow colour will be permanently fixed in the silk. The four seers of sawdust cost annas 2. To make the liquor four times and getting the silk dyed yellow costs, therefore, about Re. 1 per seer.

226. *Kamala Orange.*—Of all of the dye-stuffs used in Bengal for dyeing silk, *kamala* dust is considered the best. This substance is found as a granular deposit on the fruits of a small tree called *Pát-sindurè* (Mallotus Phillipinensis). This

tree is found in most Indian forests. The dust can be gathered in abundance in the forests of Dehra Dun, Manbhum, Singhbhum, Jalpaiguri, and of Central India. In Murshidabad, however, it is difficult to procure this article for dyeing silk, and its use is therefore extremely limited. Weavers cannot get unadulterated *kamala* dust even by paying 25 or 26 rupees for a maund. Brickdust and sand are the substances used for adulterating *kamala* dust. If the weavers are to secure pure *kamala* dust, they should propagate the trees at Mirzapur, Baluchar, Khagra, Islampur Chak, and Bashoa-Bishnupur, which are the principal centres of silk-weaving in Murshidabad. The trees being small, they fruit within four or five years after they are planted. The fruits or capsules ripen in March and April. When they ripen they burst, and that is the proper time for collecting them. The fruits are like *bar* (*Ficus Indica*) fruits. The *kamala* dust is analogous to the dust that is seen on *bar* fruits. When the fruits are not sufficiently ripe, the *kamala* dust is greenish in colour. In this state the proportion of dyeing material obtained from the dust is smaller. If the fruits, on the other hand, are allowed to get too ripe, the dust gets detached from the fruits and carried away with wind. It is important, therefore, to gather the fruits at the right time. When they are gathered at the proper time, the dust contains over 75 per cent. of dyeing material. In gathering the dust Sonthals place the fruits on a string *charpoy* (bedstead), and spread a cloth underneath. The fruits are rubbed against the strings of the *charpoy*, and the dust comes showering down on the cloth. *Anatto* trees are commonly grown by weavers close to their houses. The *kamala* dust gives a permanent colour, while the colour obtained from *anatto* is not altogether so. That it is very important to propagate the *pát-sindurè* tree in Murshidabad is therefore self-evident. The propagation of trees is not such hard work as the cultivation of agricultural crops, and one or two high-caste men can easily earn their livelihood by propagating trees yielding dye-stuffs in Murshidabad. There is no better or faster dye than what is obtained from *kamala* dust, and its introduction into the European market is also within the range of probability.

227. *The preparation of the Dye.*—Orange colouring matter is obtained not only from *kamala* dust, but also from the dust of *bar* fruits, but the latter yields a much poorer dye. In the Sonthal Parganas, Manbhum, and the neighbouring districts an orange (almost red) dye is obtained from the roots and bark at the base of the trunk of the tree called *cheli* (*Caesaria Tomentosa*). The *kamala* dust is sometimes used mixed up with *bar* dust or *cheli* wood. The mixture yields a deeper orange. *Anatto* and *bakam* (*Caesalpina Sappan*) wood are also sometimes used mixed up with *kamala* dust. These mixtures also yield a deeper orange. Used by itself, the boiled liquor imparts a straw colour to silk. In Murshidabad the *kamala* dye is prepared in this way. One pow (=½ lb.) to one pow and a half of *sáji* and a similar quantity of *lodh* dust are boiled together with about 10 seers of water. The liquor is strained out and again boiled. One pow of *kamala* dust mixed up with half a *tolá* of colza oil is put in the boiling liquor, half the quantity being put in first and the remaining quantity afterwards. A seer of bleached and mordanted silk is then introduced into the boiling liquor and well stirred until the dyeing is finished. The use of *bakam* wood in conjunction with *kamala* dust to get a deeper colour is also in vogue in Murshidabad.

228. *Cost of dyeing Silk Orange with Kamala Dust.*—

	A.	P.
(1) Mordanting a seer of bleached silk with alum ...	2	0
(2) Price of one pow of *kamala* dust	4	0
(3) Price of half a pow of *bakam* wood-dust ...	0	6
(4) Fuel for making the liquor	1	6
(5) One pow of *saji*	0	6
(6) One pow of *lodh*	0	6
(7) Labour	2	0
Total cost of dyeing a seer of silk orange with *kamala* dust	11	0

229. *Anatto Orange.*—One-half pow of *anatto* seed (price 3 annas) is boiled with 15 seers of water. Half a pow of *sáji* is powdered and got previously ready mixed up with water and strained. When the *anatto* liquor is boiling, this *sáji* water is poured into it and the boiling continued for a few minutes more. Another way of preparing the liquor is to put the *sáji* water in the plain water, tie the *anatto* seed in a piece of cloth, suspend it in the water, and get the boiling done afterwards. This saves the straining of the liquor before it is boiled again. In either case the raw silk (that is, silk which has not been bleached or mordanted) is put in the boiling liquor, got evenly dyed by stirring, washed in clean water afterwards, and got dried. To dye a seer of silk orange with *anatto* costs less than 8 annas. The *anatto* orange is not so fast as the *kamala* orange: that is, it fades gradually in time and by washing. The colour obtained by the use of *anatto* is brighter, and *anatto* is also cheaper and more readily available than *kamala* dust. The use of *anatto* is, therefore, much more common in Murshidabad and other districts than that of *kamala*.

230. *Green.*—Neither in Murshidabad nor in any other part of Bengal is the art of producing a fast green dye known to weavers. The shawl-makers of Kashmir can produce a fast green dye. How they do it, and if the dye is applicable to silk, is not yet known. Silk is dyed green in Murshidabad in the following way:—One seer of *bákash* (*Adhatoda vasica*) leaf and five seers of jack-wood sawdust are boiled together in water, strained, and a seer of bleached and mordanted silk dyed yellow by stirring in in the manner already described. The silk is then put in a " spent " indigo vat, when it becomes green. By " spent indigo vat " is meant a vat which has been already used for dyeing silk blue, and in which there is very little blue colouring matter left. If ten *tolás* of indigo are bought for 8 annas, it may be assumed that 2 annas worth of indigo still remains in the vat after it has been used for dyeing silk blue.

231. *Cost of dyeing Silk Green.*—

	Rs.	A.	P.
For bleaching	0	3	0
„ mordanting	0	2	0
Five seers of jack wood sawdust	0	2	6
Fuel for making the liquor	0	1	6
Indigo left in the "spent vat"	0	2	0
Labour	0	6	0
Total cost of dyeing a seer of silk green ...	1	1	0

(*Bákash* leaf costs nothing, as it is found in abundance everywhere.)

Fast Green.—Have 1 seer of bleached silk mordanted with ½ a seer of powdered alum mixed with 8 seers of water, and kept overnight soaked in this mixture. In the morning the silk is to be wrung nearly dry and shaken up. The same evening that the silk is soaked in alum water, a seer of dry *Sephalika* (*Nyctanthes arbortristis*) flower buds is to be kept soaked in 10 or 12 seers of water also overnight. The water with the flower buds is to be boiled in the morning, and the liquor afterwards strained out into another vessel by means of a cloth. Into this hot *Sephalika* liquor is to be plunged the mordanted silk while it is still moist, and kept stirred so that all parts of the silk may be evenly dyed. When the liquor gets somewhat cold, the silk is to be wrung out and shaken up. The remains of the flower buds on the cloth are then to be put into the liquor and boiled again for about half an hour, and the liquor strained out once more as before with the help of the cloth. The silk is to be put again into this liquor and kept inside it for an hour, occasionally stirred as before. For facility of stirring the skeins are tied with a tape and plunged in the liquor. After an hour's soaking in the liquor, the silk is to be taken out and wrung nearly dry and shaken up.

Next day have 12 seers of cold water in a *gámlá* and mix with it 2 *tolás* of aniline green, which is sold in the bazar as European green. Have the silk, while still moist, plunged into this green water and stirred in it until the desired shade of green is obtained. This green will be found to be permanent.

232. *Weight of Dyed Silk.*—It has been said a *seer* of raw silk is reduced in weight to 12 *chitaks* after it has been bleached. These 12 *chitaks* of bleached silk weigh about 12½ *chitaks* after it has been dyed. When silk is dyed green 12 *chitaks* enhance to 12½ *chitaks* in all other seasons except during the rainy season, when the enhancement in weight is ½ a *chitak* more. Silk is naturally highly hygroscopic in character. This hygroscopicity increases when it is dyed green. Twelve *chitaks* of bleached silk weigh 13½ to 14 *chitaks* after it has been dyed deep blue.

233. *Purple.*—Bleached and mordanted silk is first dyed red in the lac liquor, and then put in the indigo vat. A small quantity of lac is used that the silk may be dyed light red. The cost of dyeing silk light red is Re. 1-8 for a seer. The subsequent dyeing in the indigo vat costs another rupee. The total cost of dyeing silk purple is therefore Rs. 2-8 per seer.

234. *Chocolate* (*Banesh*).—*Banesh* is black with a shade of red. To obtain this colour the silk is first dyed deep red in the lac liquor, and it is then dipped once in the indigo vat. It costs Rs. 2-8 to get a seer of bleached silk dyed deep red. The subsequent bluing costs 12 annas. That is, the total cost of dyeing silk *banesh* is Rs. 3-4 per seer.

235. *Foreign Dyes.*—Aniline dyes imported from Europe are now in common use in Bengal. It is most convenient using these dyes, as they simply need to be mixed in water and used. Another advantage these dyes possess over the native dyes is their greater brilliance. But foreign dyes are generally fugitive, that is they wash off. By simple exposure to light for any length of time they also fade away. The use of these fugitive dyes is undermining the native silk-weaving industry. Good weavers still take the trouble and undergo the expense in producing the native dyes. One purchasing a bright-looking piece of coloured silk is very soon undeceived as to the mistake of buying silks dyed in showy colours when these colours fade away. If weavers look to their ultimate interest, they will depend on the genuine native dyes and cease to employ the fugitive dyes imported from other countries. In fact, if Native silks are to compete with European silks, reliance must be chiefly placed on the native dyes, and

they must stand by their own peculiar merits. The public can appreciate the value of native silks, which improve in appearance the more they are washed. The chief defect of European silks lies in the fact of their getting quite shabby after they are washed. It is, no doubt, a very common error prevailing among the natives of India to buy bright-looking cloths; but in course of time and with the spread of education people of this country will learn to despise bright-coloured silks, and value more and more those dyed with the old artistic native colours of the country.

236. *Starching.*—A pulp made from *khai* (parched paddy) water to which powdered *atap* rice (rice not subjected to steaming operation while in paddy) or wheat flour has been mixed and sugar-water are the substances used for applying a starch with a blunt knife (*shipi*) on a piece of silk in loom when the weaving is finished, to give it a finished look. The *khai* water is also applied with a brush on the web in the course of weaving. It enables the weaver to work the shuttle more smoothly. For "finishing" or making the ground even by working the *shipi* on the web, water alone should be used; while the use of sugar is to be particularly deprecated. The use of sugar is meant to give a gloss to the silk, but this is not the natural gloss of silk, and it comes off by washing; while a piece of silk which has been treated with sugar gets spotted and discoloured if it has to be kept in stock through a rainy season, and if it remains long, unsold, it gets actually rotten, when it tears very easily. Good weavers think it wrong to use sugar-water for finishing; but they cannot help using some kind of starch at the time of weaving.

237. *Silk-printing.*—Handkerchiefs, thin *chadders* stamped with religious texts (*námábalis*), and ordinary *chadders* (thin shawls) are printed with wooden blocks with the dyes already described. The dyes used for printing are made stronger, and a quantity of cotton-wool is mixed up with each dye for the convenience of taking it up on the block. The stamping is done on mordanted pieces of silk spread out on tables or *takta-poshes* (wooden bedsteads).

238. *Dyeing in Piece.*—The dyeing is done either in the thread or in the piece. There is a special process of dyeing in the piece, called "*bánhu.*" To make a piece of *bánhu* knots are put on a piece of silk at regular intervals with cotton threads. Thousands of knots are sometimes put on a piece before it is plunged in alum and in the dyeing vat. It is then washed in clean water, and the knots are taken out, when it is seen the knotted spots remain white, while the ground becomes dyed. The knots being put at regular intervals, the presence of the spots does not look bad, but the slight effect is produced with such enormous labour that it is hardly worth producing. *Bánhus,* in fact, are made only out of cheap *coráhs* and *matkás.* The spots are sometimes made coloured by plunging a white spotted *bánhu* in a coloured vat, when the spots take one colour, while the ground becomes altered in colour. Another process of dyeing silk in the piece is called "*momin*" or waxing. A *momin* piece is produced with drops of melted wax being arranged in regular figures in those spots which are meant to remain without colour. After this the piece is plunged in the dyeing vat and the wax afterwards removed. If the white spots are required to be coloured, the piece is afterwards put in another vat, when the spots take the colour of this vat, while the ground becomes altered in colour by the mixture of two colours. Thus, if the waxed piece is put in the yellow dyeing vat, and after removing the wax it is put in the indigo vat, the spots originally waxed take blue, while the ground is coloured green. Pieces of silk are sometimes dyed with the help of stiff clay exactly in the same way as they are dyed with the help of wax, little pellets and strings of clay being used for drawing the figures on the piece before it is mordanted and dyed. The practice also prevails of protecting portions of a piece by tying them with straps of leather or of strong cloth, plunging the piece in a dye-vat, then protecting the dyed portions, and dyeing those protected in the former operation in a different colour. In making *bánhus* knots are sometimes put with freshly coloured pieces of cotton thread, when, after the piece is dyed and the knots taken out,

little rings are formed all over the piece of the colour of the cotton thread used for knotting.

239. *Gold Embroidery.*—Two classes of embroidered silks called "reyia" (embroidered *chadder*) and "*mekhla*" (sash) are made at Baluchar in Murshidabad and exported to Assam, these being used by Assamese women. They are common-looking cloths, no very great ingenuity being required in their production. Compared to Benares-embroidered cloths they are quite inferior articles. The silk-weaving industry of Benares is thought of much more highly than that of Murshidabad throughout India; but it should be remembered gold-embroidered silk cannot be washed repeatedly and used like the white and coloured silks of Murshidabad.

240. *Dyers.*—Radda Krishna Khan and Mahesh Chandra Mandal of Khagra (Berhampore) and Bhagbadbhusan Dara of Kunjaghata (Berhampore) are the principal dyers of Murshidabad. Jaykristo Mandal, Mritunjoy Sirkar, and other principal weavers of Mirzapur, and Dubraj, the principal weaver of Baluchar, prepare most of the dyes themselves according to their own requirements.

241. The following notes by Mr. F. H. Andrews, Principal of the Mayo School of Art, regarding native methods of silk-dyeing in the Punjab will be found to be of great value:—

(1) *Colour.*—Siah Khaki (dark grey), fast.

Ingredients.—Main (*cupressus sempervirens*), 1 *chitak;* Kikar ki phali (the pod of *acacia arabica*), 1 *chitak;* Loh-i-chur (iron filings), 2 *tolás;* Phitkari (alum), 1 *tolá.*

Process.—Soak all these four things for whole night in half a seer of water. In the morning dip silk for whole day and night, and boil it next morning for about two hours. Then wash the silk in pure water and dry in the sun.

(2) *Colour.*—Surkh Khaki (red grey), fast.

Ingredients.—Maju (oak galls), 1 *chitak;* Hirakasis (an earth containing sulphate of iron), 2 *tolas;* Harir (*Terminalia cetrina*), ½ *chitak;* Phitkari (alum), 1 *tolá.*

Process.—Same as No. (1).

(3) *Colour.*—Darchini (cinnamon), fast.

Ingredients.—Darchini (cinnamon), 1 *chitak ;* Maju (oak galls), ½ *chitak ;* Kikar ka sak (bark of *acacia arabica*), 2 *tolas ;* Phitkari (alum), 1 *tolá;* Sáji (soda), 1 *tolá.*

Process.—Crush and soak first four ingredients for whole night in ½ a seer of water. In the morning dip silk for whole day and night, and boil it next morning for about two hours. Mix soda in cold water and dip silk, and wash with pure water and dry.

(4) *Colour.*—Fakhtai (dove grey), fast.

Ingredients.—Kikar ki phalli (pods of *acacia arabica*), 1 *chitak ;* Baherá (*Terminalia bellerica*), ½ *chitak ;* Amli (*imblica officinalis*), ½ *chitak;* Khatta (lime).

Process.—Crush and soak these three things for whole night in ½ seer of water. In the morning dip silk for whole day and night. Next morning boil it for about two hours. Then mix khatta in cold water and dip silk. Afterwards wash it with clean water and dry.

(5) *Colour.*—Sanduri (salmon pink), fast.

Ingredient.—Sandur (red lead), ½ *chitak;* Shingraf (cinnabar), 1 *tolá;* Phitkari (alum), 1 *tolá.*

Process.—Same as No. (1).

(6) *Colour.*—Galabi (rose), fast.

Ingredients.—Shingraf (cinnabar), 1 *tolá;* Ratanjot (*onosma echiordes*), 1 *chitak;* Phitkari (alum), 2 *tolás;* Dudh (milk), 2 *tolás.*

Process.—Grind shingraf and ratanjot together, and soak them for whole night together with alum. Dip silk for day and night; next morning boil it for two hours and wash it with clean water, again dip it in milk mixed with water and dry.

(7) *Colour.*—Piazi (rose pink), fast.

Ingredients.—Half quantity of above, No. (6).

Process.—Same as No. (6).

(8) *Colour.*—Motia, fast.

Ingredients.—Harsangar (*Nyctanthes arbortristis*), 1 *chitak;* Kesophul (flowers of *butea frondosa*), 1 *chitak;* Phitkari (alum), 1 *tolá;* Sáji (soda), 1 *tolá.*

Process.—Soak harsangar, kesophul and soda for whole night. Dip silk for a day and night. Next morning boil it for two hours. Wash it with clean water and dip again in alum with 2 *chitáks* water, and dry.

(9) *Colour.*—Basanti (yellow), fast.

Ingredients.—Asburg (yellow dye from Cabul), 1 *chiták;* Haldi chawan (turmeric), 1 *chiták;* Haldi agrai (turmeric), 1 *chitak;* Phitkari (alum), 2 *tolás.*

Process.—Crush and soak the first three things in 4 *chitaks* water for whole night, and in the morning dip silk for 24 hours. Next day mix alum and boil it for about 2 hours, after which wash it with clean water and dry.

(10) *Colour.*—Nim Basanti (light yellow), fast.

Ingredients.—Half quantity of the above, No. (9).

Process.—Same as No. (9).

(11) *Colour.*—Sandli (Sandal wood yellow), fast.

Ingredients.—Tun (flowers of *cedrela toona*), ½ *chitak;* Harsangar (*Nyctanthes arbortristis*), 1 *chitak;* Haldi agrai (turmeric), 2 *tolás;* Shingraf (cinnabar), ½ *tolá;* Phitkari (alum), 2 *tolás.*

Process.—Crush first four things except harsangar, and soak them altogether in 4 *chitaks* water for whole day and night, and dip silk for 24 hours, after which mix alum and boil. Then wash the silk with clean water.

(12) *Colour.*—Malagiri (ochre), fast.

Ingredients.—Naspal (pomegranate rind), 1 *chitak;* Maju (oak galls), 1 *chitak;* Rewand (*Rhemu Noorcroftianum*), 1 *chitak;* Hirakasis (earth containing sulphate of iron), 1 *tolá;* Khatta (lime), 1 *tolá.*

Process.—Crush first three things and soak them for whole night in ¼ seer water and dip silk for 24 hours, after which mix hirakasis and boil it for 2 hours. Then wash and apply khatta and dry.

(13) *Colour.*—Khatta (dark yellow), fast.

Ingredients.—Asburg (yellow dye from Cabul), 1 *chitak;* Haldi chawan (turmeric), 1 *chitak;* Phitkari (alum), 2 *tolás;* Shingraf (cinnabar), ¼ *tolá.*

Process.—Crush and soak these things for whole night in ¼ seer water, and dip silk for 24 hours. Next morning boil it for 2 hours, and then wash in clean water with *kalaf* (starch).

(14) *Colour.*—Narangi (light saffron), fast.

Ingredients.—Haldi chawan (turmeric), 1 *chitak;* Haldi agrai (turmeric), 1 *chitak;* Sáji (soda), 2 *tolás;* Shingraf (cinnabar), ½ *tolá;* Phitkari (alum), 3 *tolás.*

Process.—Crush and soak first four things in 4 *chitaks* water for whole night, and dip silk for 24 hours. Next morning boil it for 2 hours, and then wash it in clean water mixed with *kalaf* (starch) and alum.

(15) *Colour.*—Kesri (saffron), fast.

Ingredients.—Ekalbir (*Datisca cannabinna*), 1 *chitak ;* Haldi agrai (turmeric), 1 *chitak;* Kesophul flowers (*butea frondosa*), ¼ *tolá;* Phitkari (alum), 2 *tolás.*

Process.—Same as No. (14).

(16) *Colour.*—Sabz (green), fast.

Ingredients.—Naspal (pomegranate rind), 1 *chitak;* Ekalbir (*Datisca cannabinna*), 1 *chitak*; Haldi chawan (turmeric), 1 *chitak ;* Loh-i-chur (iron filings), 1 *tolá ;* Nil (indigo), 2 *tolás;* Phitkari (alum), 2 *tolás.*

Process.—Crush and soak first four things in ¼ seer water for whole night, and dip silk for 24 hours. Next morning mix indigo and alum, and boil as usual for 2 hours. Then wash in pure water with *kalaf* and dry.

(17) *Colour.*—Nim Sabz (light green), fast.

Ingredients.—Naspal (pomegranate rind), ½ *chitak;* Ekalbir (*Datisca cannabinna*), ½ *chitak;* Haldi chawan (turmeric), ½ *chitak;* Loh-i-chur (iron filings), ½ *tolá;* Nil (indigo), 1 *tolá;* Phitkari (alum), 1 *tolá.*

Process.—Crush and soak first four things in ¼ seer water for whole night, and dip silk for 24 hours. Next morning mix indigo and alum and boil as usual for 2 hours. Then wash in pure water with *kalaf* and dry.

(18) *Colour.*—Nil (indigo), fast.

Ingredients.—Nil (indigo), 2 *chitaks;* Gur (molasses), 2 *chitaks;* Kalai (whitening), 2 *chitaks;* Sáji (soda), 2 *chitaks.*

Process.—Soak indigo for whole night in a *chitak* of water, and grind it fine in the morning, and mix with it the other remaining things. Dip silk for 24 hours, and next morning boil it for 2 hours. Then wash it in clean water mixed with *kalaf.*

(19) *Colour.*—Ashmáni (blue or light indigo), fast.

Ingredients.—Half quantity of above.

Process.—Same as No. (18).

(20) *Colour.*—Firozi (turquoise), fast.

Ingredients.—Nil (indigo), 2 *chitaks;* Kalmi shora (nitric acid), 2 *chitaks;* Phitkari (alum), 1 *chitak.*

Process.—Soak nil for whole night in a *chitak* of water. In the morning grind it very fine, and mix kalmi shora with it. Leave it for a week in a glass or china vessel. Afterwards mix warm water and alum, and then dip silk for 24 hours. Then boil it and wash in clean water with *kalaf.*

(21) *Colour.*—Nim Firozi (light turquoise), fast.

Ingredients.—Half quantity of above.

Process.—Same as No. (20).

(22) *Colour.*—Kashni (blue), fast.

Ingredients.—Nil (indigo), 1 *chitak;* Shingraf (cinnabar), ¼ *tolá;* Phitkari (alum), 2 *tolás;* Khatta dahi (sour curd), 1 *chitak.*

Process.—Grind first three things, and mix ½ seer water, and dip silk for 24 hours. Then boil for 3 hours, and wash in clean water mixed with curd and dry.

(23) *Colour.*—Badami (almond), fast.

Ingredients.—Naspal (pomegranate rind), 1 *chitak;* Maju (oak galls), 1 *chitak;* Majit (madder), 1 *chitak;* Phitkari (alum), 2 *tolás.*

Process.—Crush and soak the first three things in ¼ seer water for whole night; mix in the morning alum, and dip silk for 24 hours, after which boil it for 2 hours and wash in clean water mixed with *kalaf.*

(24) *Colour.*—Nim Badami (light almond), fast.

Ingredients.—Half quantity of above.

Process.—Same as No. (23).

(25) *Colour.*—Atshi Golabi (bright rose), fast.

Ingredients.—Shingraf (cinnabar), ½ *tolá;* Kirm (cochineal) ½ *chitak;* Sandur (red lead), 1 *tolá;* Phitkari (alum), 2 *tolás.*

Process.—Grind these four things very fine, mix ½ seer clean hot water, and dip silk for 24 hours, after which boil it for 3 hours, and then wash with diluted milk mixed with *kalaf.*

(26) *Colour.*—Sardai (pale grey-green), fast.

Ingredients.—Asburg (yellow dye from Cabul), 2 *tolás ;* Copper rust, 2 *tolás;* Phitkari (alum), 2 *tolás;* Khatta (citron), one.

Process.—Grind these three things very fine; mix ½ seer hot water and dip silk for 24 hours, after which boil it for 3 hours, and then wash it in clean water mixed with khatta and *kalaf* (starch).

CHAPTER V.

BLEACHING AND DYEING (EUROPEAN METHODS).

242. *Principal Object.*—The main object aimed at in Europe in bleaching and dyeing silk is to obtain gloss and beauty. As a rule, it is not considered whether the processes employed will spoil the fibres of the cloth or make the colour fugitive. Indian silks and their colours are, therefore, found more lasting. Country silks, in fact, instead of deteriorating by washing, actually become brighter and softer. European silks, as a rule, become unfit for use after they are washed. When fresh, European silks look more silky than Indian silks. A piece of European silk containing 75 per cent. of cotton or linen fibre looks more silky, that is brighter, than a piece of Indian silk containing no adulteration whatever, simply on account of the processes of dyeing employed in Europe. It is very easy in this country to obtain pieces of silk containing no admixture of baser fibres; but they are not handsome in appearance like European silks, and they are therefore not so highly prized. Inferior classes of European silks can be also had at a cheaper price in this country than Indian silks. People, therefore, naturally buy large quantities of bright

foreign silks of mixed texture, instead of more genuine home-made articles. Inferior classes of European silks not only contain a mixture of baser fibres, but their silk portion is also made out of " waste." By combing and carding waste silk, very fine thread can be spun out, which is bright in appearance, but inferior to reeled thread in strength and in wear. Even in Europe, for instance, a pair of socks made out of reeled silk may cost 10*s*, while another pair, similar in appearance but made out of spun silk, may cost only 4*s*. If our weavers recognize the main object of European processes of bleaching and dyeing, they will hesitate about imitating them, and risking the reputation they now enjoy of producing lasting silks. European dyes are now commonly used in this country, but good weavers still feel a kind of shame to use these dyes.

243. *Advantage.*—If European processes of bleaching and dyeing had no advantage over the older processes, European dyers would not have abandoned the old methods in favour of the various modern inventions. The Indian processes of bleaching and dyeing are not without special faults. Bleaching silk with *sáji* and ashes reduces its lustre. One principal disadvantage of native dyes is that with their help alone it is not possible to produce various shades of dark and light colours. In fact, our dyers are unable to produce even pure red, pure black, pure yellow, and pure blue colours. By European methods, even tusser silk can be bleached and dyed, while it is no exaggeration to say we cannot bleach and dye tusser in this country. Again, it is not to be supposed that European processes must necessarily weaken the fibre and render the colour fugitive. It is, in fact, of great advantage to learn the superior processes of bleaching and dyeing employed in Europe. The processes described below are such that by their means only improvements may be effected, but no harm to the silk industry of this country.

244. *Bleaching Tusser.*—In Chapter VI, under " *Decreusage,*" will be described how mulberry silk fibre is bleached by boiling it in soap water. The details of the process are not,

therefore, given here. Bleaching silk thread with soap water does less damage to the fibre than bleaching it with *sáji.* The best soap to use is cocoanut oil soap. In Europe soap made out of olive oil is usually employed, but cocoanut oil soap is still better. Castor oil soap can be also employed for this purpose. In bleaching tusser, it is first of all necessary to " boil off " the thread in water containing soap or crystals of soda. Four seers of soda crystals should be used for 20 maunds of water, and the heating done with steam. When the water becomes 110° to 120°F in temperature, one maund of tusser thread put inside a strong linen bag is introduced in the water, and the temperature raised to boiling point (212°F), while for half an hour the bag of tusser is worked with a wooden rod. The bag is then taken out, wrung, and put in water containing vinegar. It is then again wrung and put in water containing soda crystals or soap, and " boiled " for another half an hour. For this second " boiling " a less quantity of soda crystals is used, that is, 1½ seer to 1 maund of water, and the water, instead of being raised to the boiling temperature, is raised to the temperature of 100°F only. In this water the bag of tusser thread is worked for half an hour. The skeins of thread are then taken out of the bag, wrung and dried, and then introduced into a vat containing water and hydrochloric acid. For 1½ maund of water 4 seers of strong hydrochloric acid is used. The thread is kept in this vat for half an hour, well rinsed afterwards in plain water, wrung, and dried. All the extraneous matter is expelled from the tusser fibre by the above processes, and it looks quite bright and silky; but it has not been bleached yet. It is not easy bleaching tusser white. Mulberry silk " boiled " in soda or soap water twice, for half an hour each time, gets perfectly bleached. Various methods for bleaching tusser have been invented. One of these can be easily employed in this country. After " boiling " the tusser thread twice in soda or soap water, wringing it well and drying it, it is soaked in turpentine oil, and exposed to the free action of wind and sun, being hung up in a loose condition in the open air. This exposure bleaches the thread of itself, and in a few days it will be found the fibre will have become quite white. Even after bleaching tusser white, it cannot be so easily dyed as mulberry silk. In dyeing tusser, it should be borne in mind that it requires greater heat and a greater quantity of acid (where heat and acid are required) than mulberry silk for dyes to take effect. With these two reservations, the undermentioned processes recommended in dyeing mulberry silk are applicable to tusser also.

Mulberry silk and tusser silk fibres, however they may be bleached, are not rendered absolutely white, but they retain a shade of yellow. Bleached silk dipped in the indigo vat, containing only a trace of indigo, looks perfectly white. Some native silk weavers of Murshidabad are also acquainted with this device.

245. *Black.*—Various processes are employed in Europe for dyeing silk black. The art of dyeing silk black is unknown in this country. Most of the European processes used in dyeing silk spoil the fibre to such an extent that a piece of silk dyed black usually splits in time even if it is kept for a long time simply folded up. The processes described below do not ruin the fibre in this manner.

246. (1) *Mordanting.*—Bleached silk is kept soaked in nitrate of iron solution. The object of keeping silk soaked in nitrate of iron, pyrolignite of iron, or sulphate of iron before dyeing it black is the same as that of keeping silk soaked in alum water in the processes of dyeing in vogue in this country. The proportion of one of these iron compounds used is 1 to 5 or 1 to 10 of the weight of bleached silk used. Sometimes a fourth part of alum is used with sulphate of iron in preparing the mordanting solution. That is, if five seers of silk have to be mordanted, one seer of sulphate of iron and a quarter seer of alum are used. The best result is obtained from nitrate of iron, and only half the proportion of this substance is found sufficient. In other words, only half a seer of nitrate of iron is sufficient for mordanting five seers of silk. By the use of nitrate of iron the black colour afterwards obtained partakes

of a shade of red. By the use of sulphate of iron or pyrolignite of iron, the black colour obtained has a shade of blue. If the two substances are used mixed up as mordants, a jet black colour is obtained. The mordanting is, therefore, to be done according to the shade of black desired to obtained. If by touching a piece of turmeric paper with the mordanting solution the paper does not become red, it should be inferred the solution is acid. A good result is not obtained if the mordanting solution is allowed to remain acid. To make the solution slightly alkaline, it is necessary to heat it and to stir it, while slowly pouring a solution of soda into it. A precipitate will be noticed forming while pouring the soda solution. As soon as this precipitate is noticed, the pouring of soda should be stopped. *Sáji* water may be used instead of a solution of soda crystals. The solution is to be boiled for one hour, then allowed to get cool before the silk to be dyed is introduced in it. If on putting the turmeric paper to the original solution it turns red or brown (*i.e.*, the colour obtained by mixing lime and turmeric), no addition of soda or heating of the solution is required. The silk to be mordanted is then loosely suspended from a wooden pole, which is kept continuously stirred for an hour in the solution. The pole is then taken up, the solution wrung out from the silk, washing done in plain water, the silk wrung again, and then washed in a warm soap bath for 15 minutes. For five seers of silk a quarter seer of soap should be used, and the temperature of the bath should be 180°F.

247. (2) *Density of Liquors.*—To determine the proportion of water and of a mordanting or dyeing substance to be used, a measurement rod is used. This is called Twaddle's Areometer. This rod is used for ascertaining the specific gravity of the liquors used in dyeing. The stem of the instrument is graduated so that the specific gravity of a liquor is simply read off by noting the figure down to which the rod is floating in the liquor. This specific gravity, however, is not the ordinary specific gravity recognized in modern scientific works; but it bears a definite relation to it. The figure representing the density of the liquor in the Twaddle measure,

multiplied by 0·005, and 1 being added to the product, gives the true specific gravity of the liquor. For example, a liquor of 12°Tw. is of the specific gravity of $12 \times 0{\cdot}005 + 1 = 1{\cdot}06$. The Twaddle Areometer is graduated 1, 2, 3, etc. It is necessary to have an empirical knowledge of the degree of Tw. that gives the best result for each liquor or chemical that is used for dyeing. 30° to 35°Tw. gives the best result in the case of sulphate of iron; that is, when the Twaddle measure is introduced in the solution of sulphate of iron, it ought to float up to that portion of the stem where it is marked 30 to 35. If nitrate of iron is used, the mordanting solution should be of 40° to 50°Tw. If pyrolignite of iron is used, the solution should be of 12° to 14°Tw. The specific gravity of nitrate of iron is thus the highest of the three substances mentioned.

248. (3) *First Dyeing.*—After the silk has been mordanted and washed and wrung, it should be put in a solution of prussiate of potash and hydrochloric acid. If five seers of silk are taken one seer of prussiate of potash and half a seer of hydrochloric acid and half a maund of water should be used. The solution should be kept at a temperature of 150°F, while the silk, suspended from a wooden pole, is to be kept constantly stirred in it for half an hour. After half an hour another half a seer of hydrochloric acid is to be put in, and the stirring of the silk continued for another half an hour. The silk will be now dyed blue. It should be then washed in plain water and wrung. The hydrochloric acid used for dyeing operations should be of 30°Tw., *i.e.*, the Twaddle rod dipped in the acid should float up to the mark 30.

249. (4) *Second Mordanting.*—The silk dyed blue should be treated with the nitrate of iron solution exactly as before, and washed.

250. (5) *The Catechu Bath.*—The silk is then introduced into a catechu bath. If 5 seers of silk require to be dyed, 2½ seers of catechu known as *papri-khair* should be mixed up with water, boiled and strained, and the silk then introduced in the solution. Before putting in the silk it should be seen

that the liquor stands at 4° or 5°Tw. If the areometer floats to a higher figure, warm water should be added to bring down the liquor to the requisite density. The temperature of the catechu bath should be 120°F, when the silk is put in. The silk should be kept stirred for an hour in the bath with the help of the pole from which it is suspended. It is then wrung out, put in a hot soap bath, and then rinsed in water and wrung out.

251. (6) *Mordanting again with alum.*—The silk already treated with catechu should be put in a cool solution of alum of 8°Tw. If the areometer indicates a higher degree, more water is to be added to the solution; if a lower degree than 8°Tw. more alum is to be added. After the silk has been kept stirred in the alum water for an hour, it is taken out, wrung and rinsed in plain water.

252. (7) *Second dyeing.*—The silk is then put in a liquor made with *bakam* wood (*Hœmatoxylon Campychianum*). *Bakam* or logwood tree grows in America. The heart wood of this tree is sold in almost every country in little chips, either for medicinal purposes or as a dyeing material. The tree has been introduced successfully in some gardens in Burmah, and an attempt should be made to propagate it in different parts of India. For dyeing 5 seers of bleached silk, 2½ seers of logwood should be used. It should be boiled in water for two hours, after which the density of the liquor should be 8°Tw. If a lower or a higher density is indicated, more logwood or water should be added. If more logwood has to be added, the liquor may do for steeping a larger quantity of silk than 5 seers. If another quantity of silk has to be steeped in the same liquor, all that is necessary to do is to bring back the density to 8°Tw., by the addition of more logwood, before introducing the second quantity of silk. The requisite strength of the liquor cannot be obtained simply by using a definite weight of water and of the dyeing or mordanting material. These substances are not always of the same chemical composition or of uniform purity. To get exact results, therefore,

it is necessary to ascertain the degrees of Twaddle before introducing the silk in any liquor. The same liquor may be used time after time, if each time the density is adjusted to the requisite degree. A certain amount of the mordanting or dyeing substance is taken up by the silk, which necessitates the addition of a like amount before the liquor may be used again for another quantity of silk. The same soap bath also can be used again and again for the first scouring, that is, where a second scouring in a clean soap bath or in clean water is prescribed. In a dyeing establishment, therefore, no exact weight of materials is used for a given quantity of silk. The important thing to obtain is the exact density. If in obtaining this a larger quantity of liquor than is necessary for the day's operation is got, no harm is done. The excess can be utilized in a subsequent operation. When the logwood liquor is ready, soap (one-fifth of the weight of silk taken) should be added to it, and when it is heated to 158°F, the silk should be introduced into it and kept stirred. The silk is then taken out, wrung, and finished by oiling, which is the last operation in dyeing silk black.

253. (8) *Oiling.*—The operations described above diminishing the natural lustre of silk, it is necessary to restore the lustre by the use of oil and some acid. Cocoanut oil, castor oil, earth-nut oil, cashewnut oil, and olive oil are all found adapted for this operation. Oil not mixing with water, it is saponified by shaking it up with alkaline water before it is mixed up with water. For oiling five seers of silk three *chitaks* of oil put in a bottle and shaken up for five to ten minutes with alkali water should be added to cold water, and the silk already dyed black should be kept stirred in this water for an hour. A little vinegar is to be added to the water afterwards, and the stirring continued for a few minutes more. It is then taken out, wrung, and dried. This finishes the dyeing of silk black. The black colour thus obtained is a fast colour.

254. *Red.*—Cochineal gives a purer red than lac. Both lac and cochineal are produced by two allied species of minute female insects. Lac (from *Coccus lacca*) is found on *palas* and

other trees. Cochineal (from *Coccus cacti*) is found on a few species of cactus. The colour obtained from cochineal is not quite so fast as that obtained from lac. The cochineal red does not wash out, but it gets faded in time by exposure to sunlight. The cochineal red, however, is so beautiful that its use should not be altogether deprecated. By adopting two different processes, two different shades of cochineal red are obtained. The one is *crimson*, that is red with a shade of blue, and the other is *scarlet*, that is red with a shade of yellow.

To obtain *crimson* colour on silk it should be mordanted with alum in the manner described in Chapter IV. The silk should be well kneaded in the alum solution and kept steeped in it overnight. It is then wrung out, washed in plain water, and introduced into the cochineal liquor. To dye five seers of silk deep crimson, two seers of cochineal and eight seers of water should be used. The water is boiled, and when it is boiling the cochineal is put in it, and the boiling continued for another quarter of an hour. The liquor is then strained with a cloth, and the silk introduced into it. To get most of the dye out of the cloth, the boiling water is poured into it at the time of straining. When the silk is introduced into the liquor its temperature should be 120°F. The silk should be kept stirred, while the temperature of the liquor should be again raised to the boiling point. Every now and again the silk should be taken up from the liquor, and it should be seen whether the desired shade of colour has been obtained. When this has been obtained, it should be taken up, wrung, and dried. This finishes the dyeing of silk crimson.

To dye silk *scarlet* it should be first dyed with *anatto* in the manner described in Chapter IV, and then steeped in a solution of perchloride of tin. Two seers of the tin solution should be used for dyeing five seers of silk. The tin solution is prepared in the following way:—One seer of tin crystals should be put in one seer of hydrochloric acid of 30°Tw., and heated until the crystals get thoroughly dissolved. One and a half *chitaks* of chlorate of potash are then gradually mixed up with the solution by continuous stirring. The addition of the chlorate of potash will render the tin solution deep yellow in colour. The solution so obtained is then diluted with water until its density is represented by 50°Tw. The undiluted solution has the density of 110° to 112°Tw. Silk introduced in the undiluted solution gets dissolved. Hence the necessity of diluting it sufficiently before using it as a mordant. The tin liquor into which the silk is introduced should be heated 140° or 150°F. The silk dyed with *anatto* is first moistened with water before it is introduced in the tin solution. After it has been steeped in this solution for two hours, it is wrung and well washed in plain water. It is then introduced in the cochineal vat, the dyeing being done exactly in the way described in the last paragraph. In the last paragraph it has been stated that two seers of cochineal should be used for dyeing five seers of silk, but silk already dyed with *anatto* requires only one seer of cochineal to give a bright scarlet colour. The longer the silk is kept in the boiling cochineal liquor, the deeper is the colour obtained. Thus, a deep or a light shade can be obtained either by the use of more or less cochineal, or by keeping the silk stirred in the boiling liquor for a longer or a shorter period of time.

Pure fast and bright red colour on silk can be obtained by using the aniline dyes called *primuline* and *beta-napthol.*

To 100 parts of water, 8 parts of primuline, 20 parts of common salt, and 2 parts of commercial acetic acid should be mixed up, and the whole boiled together. Into this boiled liquor the silk is introduced, and when it has taken the proper shade of colour it should be washed in plain water. It is then kept steeped for ten minutes in a cold solution obtained by mixing together one maund of water, one seer of sulphuric acid, and half a seer of nitrite of soda. After removing the silk from this solution and washing it in plain water, it is steeped in another solution while it is still wet. This solution is made by mixing together 100 parts of water, 5 parts of *beta-napthol,* and 7½ parts of caustic soda. After this operation the silk is washed in a hot soap bath, wrung out, and rinsed in water to which a little vinegar has been added. This completes the dyeing of silk bright red.

255. *Yellow.*—Of all the vegetable dyes used in Europe for obtaining yellow colour, " weld " or " wold " gives the fastest colour. This dyeing material is obtained from a shrub which grows wild in most parts of Europe and in the northern part of Africa. The silk is first mordanted with alum, and it is then introduced into a liquor made by boiling together weld and ashes in water, in which it is worked about to get it evenly dyed. The temperature of the liquor should not be above 100°F. If it is desired to obtain a deep yellow colour, ½ a seer of dry twigs of the weld plant should be used for each seer of silk. If a light yellow is desired, ¼ seer of weld should be used. For each seer of silk, 2 *tolás* only of ashes should be added in preparing the liquor. The ashes should be strained through a cloth three or four times until an oily liquid is obtained in the manner described in Chapter IV. The water in which the sticks of weld and the alkaline liquid are boiled should preferably be soap water. The boiling should go on for two hours, after which the liquor should be strained and used. When the silk has taken the proper shade of yellow, it should be brought out of the liquor, wrung, and rinsed in water containing vinegar. This last operation adds to the brightness of the colour.

256. *Aniline Yellow.*—Several yellow dyeing materials are obtained out of coal, and some of these give fast colours. The best substances to use are Chrysophenine and Titan yellow. To 100 parts of water only 2 to 3 parts of either of these substances should be used. If Chrysophenine is used, it should be mixed up with soap water to which a little vinegar has been added. If Titan yellow is used, 20 parts of common salt and a little vinegar should be added to 100 parts of water. The use of primuline which has been recommended for obtaining a pure red colour is also recommended for obtaining a greenish yellow colour on silk, this result being achieved when primuline is used with common salt water and a little vinegar.

257. *Blue.*—Some of the blue colouring matters obtained from coal give a richer and faster dye than what is obtained from indigo. Of these, Nile blue and Basle blue give the best

effect; 100 parts of soap water and 3 parts of either of these substances, well mixed together, and the silk simply dipped in this liquid, are all that is required to dye it rich blue.

258. *Green.*—Silk mordanted with alum and dyed yellow in the weld liquor is afterwards dyed green if it is dipped in the indigo vat. There are a few green colouring matters obtained from coal, which are quite fast, and at the same time brighter than the green obtained from weld and indigo. Of these, Ciruline and Anthracine green are the best. Silk mordanted with alum requires to be simply dipped in a solution made of either of these substances before it is dyed green. If 2 to 3 parts of Ciruline are used for 100 parts of water, a light green colour is obtained. If 20 per cent. of Ciruline is used, a rich green colour of obtained. If sulphate of iron is used as mordant instead of alum, and the silk is treated with a solution of Ciruline, the colour obtained is black.

CHAPTER VI.

TESTING OF SILK.

259. *Chemical Test.*—Silk cloths are often made with an admixture of baser fibres, such as jute, cotton, linen, etc. To ascertain whether a piece of cloth is made of pure silk or not, a small bit is cut out of it, introduced into a test-tube, and a little solution of Cupramonium Sulphate is added. The test-tube is heated over a spirit lamp or Bunsen flame. If the whole of the cloth introduced in the test-tube gets dissolved, it should be inferred the cloth is made of pure silk; otherwise, it should be concluded there is admixture of baser fibres. If the above re-agent is not ready at hand, the testing solution can be prepared almost anywhere without difficulty. This solution dissolves silk, but not wool, cotton, and other inferior fibres. Half a *chitak* of sulphate of copper should be dissolved in a quarter of a seer of water. Two *tolás* of glycerine are to be added to the sulphate of copper solution. This mixture is filtered through blotting paper and gathered into a glass beaker.

A solution of caustic soda is then to be dropped into the filtrate, stirring it all the while with a glass rod. As soon as the caustic soda is dropped into the filtrate a precipitate will be formed, but a slight excess of the soda will dissolve this precipitate if the stirring is continued. This clear solution should be kept bottled up and used for testing silk whenever necessary.

260. *Counting of Warp.*—To ascertain the quality of a piece of silk it is necessary to know the number of threads used in the warp, or, rather, the number of indentations in the "reed" used. In weaving superior silks a reed with 2,400 indentations per yard is used. For cloths of medium quality a reed with 2,000 indentations is used, and for cloths of inferior quality reeds with 1,200, 1,400 or 1,500 indentations are employed. A magnifying glass is used for counting the strands of thread in the warp, representing the number of indentations in the reed used. A special kind of magnifying glass is constructed for testing the warp of cloths; but any kind of magnifying glass answers for this purpose. When a specially constructed magnifier is at hand, it is not necessary to mark a space of a quarter of an inch on the cloth breadthwise. When an ordinary magnifying glass is used a quarter of an inch of space should be marked on the cloth, and the warp-threads within this space counted. If the quarter inch of space shows 16 or 17 warp-threads, it should be inferred the cloth is of superior quality, 2,400 indentations being used in the reed. If 13 or 14 warp-threads are counted, it should be inferred that there were 2,000 indentations in the reed used. If 10 or 11 warp-threads are counted, it should be inferred there were 1,500 indentations in the reed used, and so on.

261. *Testing the Colour.*—To ascertain whether the colour of a piece of silk is fast or fugitive, a little corner should be washed with soap water. If no colour comes out, it should be inferred the colour is fast. A more satisfactory test is to rub the coloured piece of silk with a piece of white linen moistened with hot alum water. If no colour comes out on the white linen, no further doubt need be entertained as to the colour of the silk being fast.

262. *Testing the Twist.*—A *pákwán* piece of silk, that is a piece made of twisted silk warp, is more lasting and more decent looking than a *kham* piece, that is one made of untwisted thread. The lasting property of a piece of silk can be more definitely judged if the number of twists given to the thread can be actually counted. As a matter of fact, *Organzine* and *Trame*, that is the threads used for the warp and the weft, are usually tested as to the number of twists there is per yard before they are bought. In this country the weft-thread is not twisted at all. In Europe, the weft-thread usually has 70 or 80 twists given to it per yard. The warp-thread in Europe is given a double twist, that is two threads are first given 400 to 500 twists per yard in one direction. They are then put together and twisted in the opposite direction 300 to 400 times per yard. To ascertain the number of twists per metre, there is an instrument called "Compteur" (see Fig. 31). In the middle of this instrument a piece of black velvet is spread out. On either end of this velvet portion there is a screw. The thread of which the twist is to be computed is attached to these two screws. The handle of the instrument is then turned in the direction opposite to that of the twist, that untwisting may take place. An indicator registers the number of turns of the handle required to untwist the thread. With a fine needle the number of fibres (*baves*) composing the thread can be also counted on the piece of velvet.

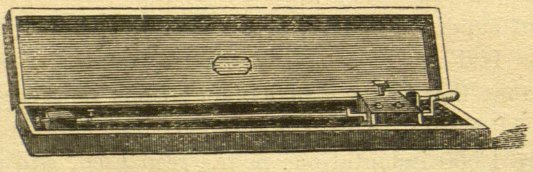


FIG. 31.—The Compteur.

263. *Testing of Strength and Elasticity.*—The instrument used for ascertaining the strength and elasticity of silk fibre is called Serimetre (Fig. 32). The compteur, serimetre and other instruments or machinery used in sericulture are constructed by M. Berthaud of Lyons and other continental constructors of machinery. The *bave* or the fibre drawn out from a cocoon is not of the same strength or elasticity throughout

its length. The fibre on the surface of a cocoon is the strongest, while that of the inner side of a cocoon finer and weaker. The reeled thread or *grege* is not of the same strength either throughout its length. The reeled thread should be as nearly as possible of the same strength throughout its length. Spinners, as a rule, work very carefully at the latter part of the day, that the skein of silk when tested superficially may look good. The top portion of a skein of silk is technically known as *Chhauni*, the portion below that is called *Pherai*, the portion coming next *Badna*, and the thread reeled first of all is called *Chik*. To test a skein of silk properly, some thread out of each of the four portions named should be gathered into four bobbins. The average tenacity and elasticity of the skein of silk can be determined by testing the thread of all the four bobbins with a serimetre. There are two screws at the stem portion of the serimetre situated half a metre (about 19½ inches) apart from each other. The thread to be tested is attached to these two screws in a vertical manner. There is a catch between the two screws. As soon as this is touched,

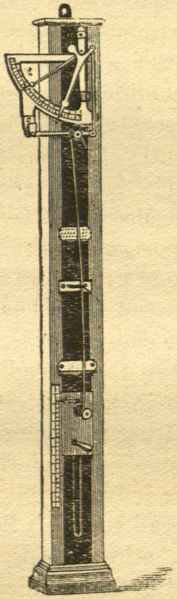


FIG. 32.—The Serimetre.

the two screws descend with the silk thread stretching between them. Owing to the elasticity of silk, the lower screw goes down faster than the upper screw, while the pointers at the arc portion of the serimetre, which are connected by a kind of clock-work with the screws below, also move up in a circle. When the screws have gone down a certain length and the pointers gone up through a portion of the arc of the index, the thread breaks, the motion of the screws and of the pointers being stopped simultaneously. The index at the lower portion of the instrument indicates the space through which the lower screw has descended. The space through which the two screws have travelled simultaneously will be indicated by the pointer moving up the inner portion of the arc. The weight which the thread has lifted when giving way is indicated at the outer portion of the arc by the second pointer or indicator. For example, let us take the case of a piece of thread tested by the serimetre. Suppose when the thread gives way the pointer at the stem portion of the instrument stands at 94 of the index plate, the pointer travelling up the outer portion of the graduated arc above indicates 25·5, and the one travelling up the inner portion of the arc indicates 11. Then the elasticity of the half a metre of thread tested is 94 – 11 = 83, and that of a metre 83 × 2 = 166. In other words, the elasticity of the thread is 16·6 per cent.: 25·5 indicates that the thread has lifted the weight of 25·5 grammes (about half a *chitak*) before breaking.

264. *Testing the "Size."*—"*Denier*" is the name applied to an old French weight which is still kept up in testing the "size" of silk. Nineteen *deniers* is equivalent to about 1 gramme. A special kind of scale is used (see Fig. 33) for

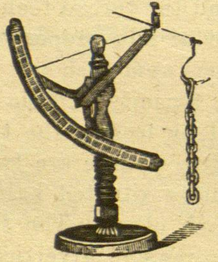


FIG. 33.—Denier Scale.

weighing little skeins of silk thread measuring 476 metres in length, the weight being indicated by the pointer of the scale in *deniers*. To obtain test skeins (*kilchis*) of silk 476 metres long, a special kind of " testing " machine is constructed (see Fig. 34). Four *kilchis* or test skeins should be taken out of the four bobbins containing, respectively, the *Chhauni*, *Pherai*, *Batna*, and *Chik* threads, and the average " size " of the skein tested by weighing the four *kilchis* one after another in the *denier* scale. If the four skeins weigh exactly the same, the spinner and the winder should be rewarded. If the weight varies very much, that is, if one *kilchi* weighs 11 *deniers*, another 10, another 14, and so on, the spinner should be punished for making thread so uneven. The diameter of the wheel of the testing machine is $\frac{476}{400}$ metres, *i.e.*, about 45 inches. A thread being attached to the wheel, the handle of the machine is kept working until a clock strikes mechanically, when the turning of the wheel should be stopped at once. The clock strikes after 400 revolutions of the wheel, that is, when 476 metres of thread have been gathered into the wheel. All the four bobbins can be attached to the machine at the same time, and four test skeins obtained simultaneously. The little skeins are taken out of the wheel, twisted up, and weighed in the balance as indicated in Fig. 33. At each weighing it should be noted what figure in the index the pointer indicates. This figure gives the weight of the skeins in *deniers*.

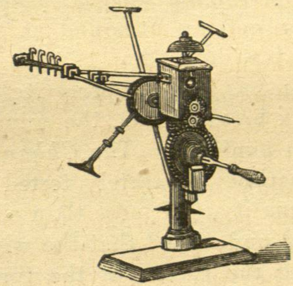


FIG. 34.—The Testing Machine.

265. *Testing the Winding.*—To keep a check over the work of the spinner it is not only necessary to test the " size " of a number of skeins of thread daily reeled in a factory, but it is

also necessary to unwind some skeins into bobbins. The skeins to be tested are untwisted and put in a loose manner on the reels arranged at the lower portion of the unwinding machine. The ends of the skeins are found out and attached to the bobbins arranged on the upper portion of the machine. When the handle of the machine is turned, the bobbins also revolve, the skeins getting unwound at the same time. If after 45 minutes' testing no breaks take place, it should be concluded the skein has been properly reeled. If during this time more than six breaks occur, the spinner and the winder both deserve to be punished. The *Chhauni*, *Pherai*, *Badna*, and *Chik* are sometimes separately tested for 45 minutes as to their winding quality. If more than six breaks take place it should be chiefly understood that the winder has been careless about knotting the thread at the time of reeling when breaks took place, that is, instead of putting a knot when a break took place at the time of reeling, he made the attachment of the thread anyhow on the reel, and went on with the winding. Bengal raw silk breaking every now and again at the time of winding, the use of Bengal silk in most departments of European manufacture has become obsolete. Skeins of properly reeled silk give so little trouble in unwinding that one girl is usually employed in European factories for looking after the unwinding of 100 skeins at a time. Bengal raw silk breaks so often in unwinding that one girl has to be employed for each 20 or 30 "tavelles," that is, the wheels on which the skeins are spread out loosely for unwinding. The girls are employed to find out the ends and put knots whenever breaks take place. Good raw silk is, therefore, technically known as a "100-tavelle silk;" while inferior silks are classed as "20-tavelle," "30-tavelle," etc. There is another reason for the Bengal silk giving so much trouble in unwinding. When the day's work is done in a Bengal filature, the winders are employed to pick out all the "knibs" or slovenly portions from the skeins in reel. This operation breaks the continuity of the thread in several places. But if the knibs are not picked out, a skein of silk looks inferior, and a smaller price is obtained for it. Bengal cocoons being small and inferior, it is impossible to avoid knibbiness altogether. A European cocoon contains four times the length of fibre of a Bengal cocoon. European raw silk thus necessarily contains less joinings than Bengal silk. Again European cocoons and the chrysalides inside them being heavier, they do not jump out of the basin every now and again at the time of reeling. Cocoons getting entangled in the basin sometimes, they jump up from the basins, and the consequence is entanglement of rough bits of thread with the fibres reeled off. For all these reasons, there is very little hope of Bengal silk ever coming to be recognized as a " 100-tavelle " silk. If, however, Bengal raw silk is re-wound and throwsted in this country before export, no objection can arise to its being utilized in European processes of manufacture.

266. *Testing the Fineness of Fibre.*—The fineness of fibre of a particular class of cocoons is ascertained by measuring the diameter of the fibre with the help of a microscope fitted is with a micrometer eye-piece. The diameter of silk fibres is expressed in the term of micromillemetre. A metre is a little over 39 inches. A millemetre is the thousandth part of a metre, and a micromillemetre is the thousandth part of a millemetre. Silk fibres of all kinds are as a rule made up of two ultimate fibres. The mulberry silkworm and most other silkworms are furnished with a pair of silk glands. From these come out two gelatinous fibres, which unite just outside the mouth of the silkworm. If a silk fibre (*bave*) is examined under a microscope, it will be found to be composed of two ultimate fibres (*brin*) agglutinated together. By a fibre of silk is, therefore, to be understood a double fibre. The diameter of this double fibre, expressed in inches, must be expressed in fractions. It is more convenient to express them in whole numbers in the term of micromillemetres thus :—

				Micromille
Diameter of the fibre of	European cocoons		...	25 to 33
,, ,,	Chhotapalu	,,	...	20 ,, 24
,, ,,	Nistári	,,	...	17 ,, 21
,, ,,	Barapalu	,,	...	16 ,, 18
,, ,,	Bengal tusser	,,	...	76 ,, 90
,, ,,	China ,,	,,	...	60 ,, 65
,, ,,	Endi ,,	,,	...	40 ,, 50
,, ,,	Muga ,,	,,	...	60 ,, 65
,, ,,	Yamamai	,,	...	43 ,, 46

Of all kinds of silk fibres in use, the *Barapalu* and the *Nistári* cocoons possess the finest, and the Bengal tusser the coarsest fibre.

267. *Testing Cocoons*.—Fresh or green cocoons weighed on the third day after spinning and counting give the quality of the cocoons in the terms of so many *puns* (*pun*=80) to the *seer*. The quality is also expressed (after cocoons have been reeled) in the terms of so many *káhans* of cocoons (*káhan*=1,280) going to make a *seer* of silk. The quality of a class of cocoons is also judged by the proportion of reelable silk-waste and chrysalis it contains.

268. *Testing the Moisture.*—Silk is such a hygroscopic substance, that in buying a *maund* of it, one may get only 34 or 35 seers of silk, and 5 to 6 seers of excess of moisture without being aware of it. Five or six seers of water have no value whatever, while the value of this quantity of silk is more or less Rs. 100. In buying a large quantity of silk, the possibility of making a bad bargain in this respect is so great, that a sample is always got tested in Europe with regard to the proportion of moisture it contains. In fact, the principal work of " conditioning " establishments in Europe is testing of moisture in silk. Naturally almost every substance contains a certain amount of moisture. If 111 parts (in weight) of silk is dessicated with heat, 11 parts ought to vanish in the form of water-vapour, and 100 parts of pure silk ought to remain behind. From January to May Bengal silk contains less than 10 per cent. of moisture on account of the excessive dryness of the atmosphere during this period. From July to September it may contain as much as 20 per cent. of moisture, as the air during these months is surcharged with moisture. Of these 20 per cent., 10 per cent. should be deducted on account of the natural moisture of silk; but the remaining 10 per cent. is liable to be bought at the price of silk, as it remains latent without being perceived by mere outward tests. Silk is such a valuable substance that it is a mistake to deal largely in this fibre without getting it tested for the moisture it contains. In France there are 20 conditions houses, which are employed chiefly in testing the moisture in raw silk. The testing is done in the following way. A bale of silk presented for " conditionment " is first weighed, and the weight

noted down. The bale is then opened out, the outer sack, the wax cloth, the inner cotton cloth, wrapper, the strings and any papers, etc., in the bale are then separated out and weighed, and this weight also noted down. Ten skeins are then taken out of the bale from five different parts, two skeins from each part of the bale. Five skeins taken from the five different portions of the bale are dessicated in one room, and the other five skeins in another room. Lest any error should occur in the work in one room, each sample is analysed in two different rooms. The weight of the five skeins of silk is noted down before they are introduced in the oven. A balance is fitted to the oven, immediately above it. After taking down the weight of the skeins before dessication, the cover of the oven is removed, the scale pan on the right-hand side of the balance, with the five skeins of silk loosely hanging from it, is put inside the oven, and the cover drawn down again. The right-hand scale pan gradually rises, a hole in the cover allowing this free movement, for about 20 minutes. In about 20 minutes the whole of the moisture having escaped, no further oscillation of the balance is noticed. The dry weight of the skeins is now noted. The difference between the original weight of the five skeins and the dry weight gives the amount of moisture. If this difference is only 11 per cent. of the dry weight, it is concluded there is no excess of moisture in this silk. Anything above the 11 per cent. is regarded as excess moisture.

269. *Decreusage.*—The net weight of silk is that which is obtained after it is " boiled off " or bleached. The weight lost by the *Decreusage* or " boiling off" is the weight of foreign matter and natural gum or *gres* which surrounds the fibre of silk as it comes out of the mouth of the silkworm. Besides this natural gum, there adheres to reeled silk the impurities of the water and of the chrysalides of the reeling basin. The operation of *decreusage* removes the *gres* and the impurities from the silk, and the residue obtained is pure silk. To ascertain the amount of refraction due to *gres* and impurities by the process called *decreusage*, which corresponds to bleaching, in the case of mulberry silk, a soft soap called *Savon Marseille*

is used. The substances entering into the composition of this soap are olive oil, sodium hydrate, and sodium carbonate. It is clear white in appearance. A quarter seer of this soap is used for boiling off one seer of silk. The soap and water are mixed together in a copper vat, and the boiling done by steam. The skeins of silk are loosened out, protected from getting entangled afterwards by tying each with a piece of ribbon, and then introduced into a canvas bag. This bag is put in the boiling soap water, and it is constantly stirred with a wooden pole. After stirring it in this vat for half an hour it is removed to another vat of boiling soap water, where it is kept stirred for another half an hour. The excess of water is now wrung out from the bag, the bag is then put in a warm bath containing water to which a little vinegar has been added, and the final rinsing is done in distilled water at 40°C, after which the skeins are brought out and dessicated in the manner described in paragraph 268, and weighed. To the dry weight is added 11 per cent. on account of natural moisture. The residual loss of weight is to be accounted for partly by the excess of moisture, and partly by the escape of *gres* and impurities in the *decreusage.* The weight of the excess of moisture being ascertained in the manner described in paragraph 268, the loss of weight due to *grés* and impurities can be easily inferred. Mr. Thomas Wardle has ascertained, in this way, that Bengal raw silk loses on the average 30 per cent. of its weight in the "boiling off," European raw silk 28 per cent., China raw silk 27 per cent., Japan raw silk 30 per cent., China tusser 21 per cent., and Bengal tusser 11 per cent. That tusser loses less in weight by the "boiling off" process than mulberry silk is to be explained by the fact that the impurities of tusser cannot be entirely taken off by scouring it in soap or *saji* water. The process by which tusser can be cleaned and bleached has been described in Chapter V.

270. *Result of Tests.*—The table given below will enable one to judge of the relative merits of the various types of commercial cocoons as these have been ascertained by the application of the aforementioned tests:—

Relative Merits of Cocoons.

CLASS OF COCOONS.	Yellow variety of France.	Round white Ascoli Picens or Shanghai cocoons of Italy.	Bivoltine white Pai-pi-tsan of China.	Yellow Japanese cocoons.	White Barapalu of Bengal.	Nistári cocoons.	Chhotapalu cocoons.	Wild Theophila Huttoni cocoons.	Endi cocoons.	Bengal tusser.	China tusser.	Yamamai cocoons of Japan.	Muga cocoons of Assam.	Attacus Atlas.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Average weight of a fresh cocoon in millegrammes.	1,850	...	...	...	750	600	620	...	...	9,000	6,000	...	3,000	...
2. Average depth and length of cocoons in millemetres.	19 × 36	18 × 25	16 × 25	14 × 25½	15 × 30	13 × 25	11½ × 31	16 × 33	...	28 × 45	22 × 43	25 × 44	23½ × 45½	30 × 80
3. Average length of fibre in a cocoon in metres.	840	580	240	300	270	210	215	...	...	700	550	...	260	...
4. Weight of frisson or jhut on a cocoon in millegrammes.	32	1½	6½	9	13½	11½	11	...	...	90	63	...	25	...
5. Weight of *telette* or *topá* of each cocoon in millegrammes.	20	3½	12½	10	6½	5⅓	5⅓	...	...	44	55	...	20	...
6. Weight of reelable silk in each cocoon in millegrammes.	250	115	41	71	60	36	45	...	...	720	300	...	125	...
7. Proportion of reelable silk in the fresh cocoon per cent.	14	14½	...	...	8	6	7¼	...	...	8	5	...	4	...
8. How the cocoons reel off ...	Very well.	Very well.	Fairly well.	Fairly well.	Fairly well.	Fairly well.	Fairly well.	Fairly well.	Very badly.	Indifferently.	Indifferently.	Fairly well.	Not badly.	Very badly
9. Diameter of *bave* in millemetres	30	23½	23½	22⅘	16½	20	20⅓	25	45	47	62	46	46	40
10. Average weight of test skeins of *bave*, 476 metres long, in *deniers*.	2⅘	1⅘	1½	2⅕	2⅓	1⅗	2	2	...	9	5	...	4	...
11. Tenacity of *bave* in grammes ...	10	6	5	7¼	6⅓	4	5⅘	12⅓	7	28½	18	25	14	8
12. Percentage of elasticity of *bave*	14	11½	7	10½	16	12	12½	13⅓	18	21½	19	...	18½	...
13. Number of fresh cocoons per seer	500	...	...	...	1,000	1,350	1,350	...	700	100	160	...	350	...
14. Number of dry cocoons per seer	1,300	2,300	5,500	3,100	3,000	4,800	4,000	...	2,000	300	500	...	9,000	...
15. Percentage of loss in weight due to *decreusage*.	23	27	27	30	24	25	30	...	...	11	21	...	...	...

CHAPTER VII.

PREPARATION OF SILKWORM-GUTS.

271. There is great advantage in utilizing the ripe fly-blown silkworms in the preparation of guts by plunging them into a bottle of vinegar instead of giving them the chance of making cocoons (and thus helping to multiply the parasite). The silk glands can be afterwards taken out of these worms and drawn into guts which are used for tying fishing hooks with. The silk glands of European silkworms being much larger, they produce much longer guts than the glands of Chhotapalu, Barapalu or Nistári silkworms. Any silkworms that may be set apart at the time of ripening for the preparation of fishing-guts should be drowned in a bottle of vinegar in the ripe and live condition. After they have been in the vinegar for six hours they should be taken out of the bottle, and the silk glands picked out of them one after another. The two ends of a gland are to be held with the fingers of the two hands of the operator, and the gland gradually stretched. If it does not stretch out evenly, the thick portions can be thinned out separately. The stretching should be done slowly and steadily that the gut may not become too fine. Each silk gland should be lengthened out from 9 inches to a foot. When it has been thus stretched out, the ends should be fastened to pins and the gut passed through the thumb and the index finger only in one direction, the friction given being very slight. This operation makes the gut smooth and tense. The silkworm-gut is the strongest thread of the same fineness that can be employed. As vinegar is not always of the same strength, six hours' submergence in it may prove too little or too much. If on stretching a silk gland it is found too soft and yielding, it should be inferred that it requires to be kept in vinegar a little longer; if, on the other hand, it does not stretch at all, and it is found to be brittle, it is to be inferred that it has been kept too long in the vinegar. It is not possible to make gut out of a gland that is yet too soft or which has become hard and brittle. The worms should be so long in vinegar as will make the gland stretch firmly and

steadily. The vinegar ordinarily sold in the bazar requires six hours' steeping before the guts can be properly made. When a gut has been made it is put in water and afterwards wiped dry, and is then ready for use. When tying a fishing-hook with it it should be previously soaked in water for about ten minutes. In the Calcutta market silkworm-guts imported from Europe sell at the rate of 16 to 100 per rupee. Making guts from ripe silkworms is thus a very lucrative handicraft. Silkworms affected with muscardine (which is attended with an acid secretion), at the last stage, yield glands which can be stretched into guts without steeping them in vinegar.

CHAPTER VIII.

ARTIFICIAL SILK.

272. European chemists have been for the last ten years trying to make silk fibre by chemical processes out of ordinary vegetable fibres. These trials have not proved altogether fruitless. An artificial silk was first manufactured by M. Chardonet, a French chemist; and quite recently a Swiss chemist, Dr. Frederic Lehner, has given the world an artificial silk superior to the Chardonet silk. At Bradford, a silk-weaving town in England, a Joint-stock Company with a capital of £100,000 has been formed for working the Lehner process. The general method of manufacture is the same in both processes. The Lehner and Chardonet silks are both almost equally explosive substances. It cannot be safe keeping a large store of cloths made out of such explosive substances, or shipping them in bales from one country to another. Whether cloths made out of these artificial silks will prove as lasting as those made out of natural silk, and whether the dyes applicable to natural silk will prove equally applicable to these artificial silks, yet remains to be proved by experience. In course of time chemists may succeed in manufacturing an artificial fibre in every way superior to natural silk, and thus ruin the, silk-rearing industry as it is at present carried on. The

results of the tests applied to the Chardonet silk at the Sericultural Laboratory of Lyons are tabulated below (*vide* Report of the Laboratoire d'études de la Soie for 1891):—

	Chardonet silk.	European mulberry silk.	China tusser.
1	2	3	4
1. Elasticity ...	11·6	17·2	18
2. Tenacity of *bave* ...	13·6	6·8	8·4
3. Tenacity of raw silk of 10 *deniers.*	17	48	38
4. Diameter of *bave* ...	70 micromillemetres.	20 micromillemetres.	50 micromillemetres.
5. Temperature at which the silk dissolves in a 40 per cent. solution of caustic potash.	50°C.	80°C.	100°C.

From the above table it can be easily inferred that the artificial silk invented by Chardonet is very much inferior to natural silk. In outward appearance, however, artificial silk is not in any way inferior to natural silk.

273. The general process by which artificial silk can be manufactured will now be described. The basis of this manufacture is cellulose. Wood fibre, cotton, linen, jute and other vegetable fibres, if they are digested, that is boiled for a time, first with an acid solution and then with an alkaline solution, the residue which is left is cellulose. If strong nitric acid is added to cellulose and then a smaller quantity of sulphuric acid, a pulp will be formed which will contain various nitrates of cellulose. Some of these nitrates of cellulose (Cordite, Tonite, etc.) are more explosive than gunpowder: others, however, are not so explosive. These latter are called pyroxylin nitrates. If equal parts of alcohol and ether are added to the pulp already mentioned, and thoroughly mixed up with it, the highly explosive nitrates can be easily separated from the pyroxylin nitrates, the former not being soluble in alcohol and ether. The glutinous substance expressed out of the pulp

by pressure will not contain the highly explosive compounds of the pulp. This glutinous substance passed through fine orifices by the application of great pressure, and washed with water, is the artificial silk. To lessen the explosive property of the substance still further, the fibres obtained are treated with a solution of ammonium sulphide and dried immediately afterwards.

" The following methods are recommended for the detection of artificial silk. Mr. P. Truchot, in the *Annales de Chimie Analytique,* says that in burning no acid vapours are evolved, nor is the odour of burned horn noticeable. Schweitzer's agent largely swells both kinds of silk before they pass over into solution; an addition of water or hydrochloric acid precipitates the artificial silk as a white, flaxy cellulose. When dissolved in pure sulphuric acid (66° Bé) artificial silk forms a deep yellow syrupy fluid, which is coloured dark blue by the addition of a solution of diphenilamine sulphate. The presence of artificial silk may also be detected direct, without solution, by dipping a small clipping of the fabric to be examined into a solution of diphenilamine sulphate, whereby every thread of the artificial silk is tinged dark blue, while natural silk remains entirely unaffected. Without resorting to chemical methods, a very simple way of recognizing artificial silk is given in the *Dry Goods Chronicle,* and one which ought to be invaluable to buyers of dress goods. A wood-pulp silk is now used to a large extent in foreign-made fancy goods to give a brighter effect than can be imparted to the fabric by the use of natural silk. The test is to unravel the threads of the fabric, and put the silk strands into the mouth and masticate them vigorously. Artificial silk readily dissolves under this operation, and breaks into minute particles, and when pulled between the fingers shows no thread but a mash of cellulose or pulp. Natural silk, no matter how thoroughly it is masticated, will retain its fibrous strength. The artificial silk offers no resistance to the teeth, which readily go through it, whereas natural silk does. It is sufficient to moisten the thread on the tongue, and then submit it to a pulp between the fingers. Natural silk will resist a strong pull, wet or dry." (*Indian Textile Journal,* December 1897.)

CHAPTER IX.

SILK TRADE.

274. *Trade.*—What quantities of silk are produced in the different countries, what quantities are imported into these countries, what quantities are exported out of them, and what quantities are utilized in them for manufacturing purposes can be gathered from a number of tables given in the work entitled L'Industrie de la Soie en France (1894), by M. Natalis Rondot of Lyons, the greatest authority on sericultural statistics. These, therefore, are quoted below:—

275. *Production.*—

COUNTRY.	Silk.	Waste.	Total Production.
1	2	3	4
	Kilogrammes.	Kilogrammes.	Kilogrammes.
China	10,500,000	8,500,000	19,000,000
Japan	3,900,000	3,200,000	7,100,000
Indo-China ...	950,000	750,000	1,700,000
India	625,000	550,000	1,175,000
Central Asia ...	1,040.000	865,000	1,905,600
European Russia ...	......	......	......
Asiatic Turkey ...	700,000	650,000	1,350,000
Turkey in Europe ...	160,000	50,000	210,000
Balkan States ...	30,000	15,000	45,000
Greece	35,000	20,000	55,000
Austria and Hungary ...	265.000	320,000	485,000
Italy	4,200,000	3,600,000	7,800,000
France	720,000	600,000	1,320,000
Spain and Portugal ..	80,000	50,000	130,000
Switzerland ...	30,000	50,000	80,000
Germany	......	5,000	5,000
Great Britain ...	......	30,000	30,000
Morocco	5,000	5,000	10,000
United States and Canada	5,000	50,000	55.000
Mexico	1,000	......	1,000
Total ...	23,246,000	19,210,000	42,456,000

276. *Importation.*—

COUNTRY.	Silk.	Waste.	Total Importation.
1	2	3	4
	Kilogrammes.	Kilogrammes.	Kilogrammes.
China	Nil	Nil	Nil
Japan	10,000	2,000	12,000
Indo-China ...	175,000	......	175,000
India	600,000	600,000	1,200,000
Central Asia ...	40,000	......	40,000
Russia in Europe ...	450,000	200,000	650,000
Arabia	12,000	......	12,000
Turkey in Asia ...	200,000	......	200,000
Do. in Europe ...	2,000	......	2,000
Balkan States ...	6,000	......	6,000
Austria and Hungary ...	500,000	540.000	1,040,000
Italy	1,400,000	765,000	2,165,000
France	5,310,000	6,590,000	11,900,000
Spain and Portugal ...	125,000	......	125,000
Switzerland ...	2,175,000	1,300,000	3,475,000
Germany	2,390,000	900,000	3,290,000
Belgium	75,000	......	75,000
Great Britain ...	1,140,000	3,290,000	4,430,000
Egypt	170,000	......	170,000
Tunis and Tripoli ...	75,000	......	75,000
Algeria	30,000	......	30,000
Morocco	65,000	......	65,000
United States and Canada	2,650,000	630,000	3,280,000
Mexico	10,000	......	10,000
Australia	......	140,000	140,000
Total ...	17,610,000	14.957,000	32,567,000

277. *Exportation.*—

COUNTRY.	Silk.	Waste.	Total Exportation.
1	2	3	4
	Kilogrammes.	Kilogrammes.	Kilogrammes.
China	4,500,000	3,780,000	8,530,000
Japan	2,840,000	1,800,000	4.640,000
Indo-China ...	75,000	120,000	195,010
India	160,000	600,000	760,000
Central Asia ...	125,000	630,000	755,000
Turkey in Asia ...	620,000	550,000	1,170,000

COUNTRY.	Silk	Waste.	Total Exportation.
1	2	3	4
	Kilogrammes.	Kilogrammes.	Kilogrammes.
Turkey in Europe ...	135,000	20,000	155,000
Balkan States ...	10,000	......	10,000
Greece	22,000	......	22,000
Austria and Hungary ...	415,000	385,000	800,000
Italy	5,200,000	1,670,000	6,870,000
France	2,430,000	1,900,000	4,330,000
Spain and Portugal ...	50,000	40,000	90,000
Switzerland ...	740,000	700,000	1.440,000
Germany	490,000	550,000	1,040,000
Belgium	20,000	......	20,000
Great Britain ...	105,000	435,000	540,000
Egypt	4,000	......	4,000
Total ...	18,191,000	13,180,000	31,371,000

278. *Consumption of Mulberry Raw Silk.*—

COUNTRY.	Home-made.	Foreign.	Total Consumption.
1	2	3	4
	Kilogrammes.	Kilogrammes.	Kilogrammes.
China	5,750,000	......	5,750,000
Japan	1,150.000	10,000	1,160,000
Indo-China	1,000,000	175,000	1,175,000
India	475,000	625,000	1,100,000
Central Asia ...	850,000	......	850,000
Russia in Europe ...	......	450,000	450.000
The Levant	115,000	400,000	515,000
Austria and Hungary ...	100,000	360,000	460,000
Italy	150,000	250,000	400,000
France	650,000	2,950,000	3.600,000
Spain and Portugal ...	40,000	120,000	160,000
Switzerland ...	......	1,400,000	1,400,000
Germany	......	1,900,000	1,900,000
Great Britain ...	......	900,000	900,000
United States and Canada	......	2,650,000	2,650,000
Mexico	......	10,000	10,000
Egypt, Tunis, Algeria, and Morocco	......	250,000	250,000
Total ...	10,280.000	12,450,000	22,730,000

279. *Consumption of Spun Silk.*—

COUNTRY.	Home-spun.	Foreign.	Total Consumption.
1	2	3	4
	Kilogrammes.	Kilogrammes.	Kilogrammes.
China	1,500 000	......	1,500,000
Japan	400,000	......	400,000
Indo-China ...	200,000	......	200,000
India	20,000	200,000	220,000
Central Asia ...	215,000	......	215,000
Russia in Europe ...	......	100,000	100,000
The Levant ...	20,000	......	20,000
Austria and Hungary ...	100,000	130,000	230,000
Italy	200,000	30,000	230,000
France	1,100,000	500,000	1,600,000
Spain and Portugal ...	......	40,000	40,000
Switzerland ...	125,000	......	125,000
Germany	250,000	950,000	1,200,000
Great Britain ...	550,000	......	550,000
United States and Canada	190,000	10,000	200,000
Mexico	......	5,000	5,000
Egypt, Tunis, Algeria, and Morocco	......	90,000	90,000
Australia	......	5,000	50,000
Total ...	4,870,000	2,105,000	6,975,000

280. *Total Consumption of Silk Thread.*—

COUNTRY.	CONSUMPTION. Kilogrammes.
China	7,250,000
Japan	1,560,000
Indo-China	1,375.000
India	1,320,000
Central Asia	1,065,000
Russia in Europe	550,000
The Levant	535,000
Austria and Hungary	690,000
Italy	630,000
France	5,200,000
Spain and Portugal	200,000
Switzerland	1,525,000
Germany	3,100,000
Great Britain	1,450,000
United States and Canada	2,850,000
Mexico	15,000
Egypt, Tunis, Algeria, and Morocco ...	340,000
Australia	50,000
Total ...	29,705,000

281. *Silk Trade of India.*—An erroneous opinion has become quite current that the silk-weaving industry of India has declined in the same way as the cotton-weaving industry. For various reasons, hereafter to be detailed, the silk-weaving industry of India has declined to some extent, but its magnitude and importance still deserve recognition. The silk industry cannot be said to be established on a firm and stable basis in any country where the manufacturing processes alone take place, but where the raw material is not produced. The silk trade of Germany, Great Britain, the United States, Canada, Australia and other countries where silk cloths are manufactured, but where little or no cocoons are raised, is unstable. The trade is established on a firm basis in countries where the three following conditions co-exist : (1) production of the raw material; (2) manufacturing skill; and (3) demand for the produce. All these three conditions co-exist in India. (1) *Paundraka* caste has been employed from the most ancient times in rearing cocoons. So long as the caste system will remain in force, the *Pundás* of Bengal will continue to rear cocoons, whether they prosper on this industry or not. (2) The gold-embroidered silk *saris*, &c., of Benares, and the white, coloured and check silk pieces, *saris*, and handkerchiefs made at Mirzapur in Murshidabad are inferior to no other silks in manufacturing skill. (3) The cotton and woollen cloths produced in India may or may not be used by Indians; but there is not such liberty allowed by Hinduism in the matter of silk cloths. No Hindu may use foreign silks (wearing of silk being obligatory) for the various religious ordinances, such as weaning, drilling of the ears, investiture with the sacrificial thread, marriage, &c.. and also for daily worship. In imitation of the Hindu custom, the Muhammadans and Parsis of India also use Indian *chelis* and other kinds of silks on special ceremonial occasions. Of the 625,000 seers or kilogrammes of raw silk produced in India, only 160,000 seers are exported. In addition to the remaining 465,000 seers of home-reeled thread, 625,000 seers of foreign thread imported into India are utilized for weaving the very large quantity of indigenous

silk cloths that are in demand in the country. In fact, the silk-manufacturing industry of India is very much more important than the export trade in silk. The figures given in the above tables for the production and consumption of silk thread in India are not altogether reliable. In hundreds of villages in Murshidabad and other silk districts pierced cocoons are spun into coarse thread, out of which *matká* cloths are woven. These cloths are not only in common use in villages in these districts, but they are also largely used by Mahrattas and other Hindus who wear *matká dhotis* after their morning bath. The figures given in the table for the production of waste silk in India may not be unreliable, as it is reasonable to suppose that the production of 625,000 seers of raw silk would result in the production of 550,000 seers of waste. The figure in the table for import of waste silk, *viz.*, 600,000 seers, is most likely correct. The total of these two figures is 1,150,000 seers. Of this, 600,000 seers of "waste" are exported from India to foreign countries. The remaining 550,000 seers of waste ought to produce 500,000 seers of coarse (*matká*) thread, while the table accounts for 220,000 seers only as the quantity utilized in the country. The figure ought to be at least doubled. Taking all facts into consideration, the silk industry of India occupies a place lower only to that of China, Japan, Italy and France. Every well-wisher of India should do something to strengthen the three foundations on which the stability of her silk trade depends.

282. *Export from India.*—The export in the total quantity of silk has not materially altered during the last 40 or 50 years:—

	Seers.
In 1867-68 the export was	1,113,000
,, 1887-88 ,, ,, ...	813,000
,, 1892-93 ,, ,, ...	920,000

Although the quantity has not diminished very materially, the value of the export has become only a third of what it was. The value of the silk exported in 1867-68 was over one crore and fifty lakhs of rupees, while the value of that exported in 1887-88 was only forty-eight lakhs of rupees, and of that exported in 1892-93, sixty-one lakhs of rupees. The diminution in the export would have been still more precipitate if the value of the rupee had stood at 2 shillings, as of old. The influx of money into India has increased through other channels, *viz.*, jute, tea, rice and oilseeds, the value of the export of any one of these articles being much greater than that of silk. Another consideration will also show the decline of the export trade in silk during recent years. The crore and a half of rupees worth of silk annually exported in former years represented the value of raw silk, *i.e.*, filature-reeled silk only. The average value of the raw silk exported now is only about forty lakhs of rupees per annum. Previous to 1860 the export of waste silk was unknown. The following table gives a comparative view of the export of raw silk, waste, and pierced cocoons for ten years:—

	Silk.	Waste.	Cocoons.	Total Value.
Year.	Seers.	Seers.	Seers.	Rs.
1883-84 ...	318,000	443,000	22,000	62,75,000
1884-85 ...	265,000	476,000	46,000	46,38,000
1885-86 ...	179,000	512,000	28,000	33,22,000
1886-87 ...	224,000	510,000	57,000	48.43.000
1887-88 ...	226,000	499,000	86,000	48,08,000
1888-89 ...	216,000	657,000	187,000	51,87,000
1889-90 ...	296,000	616,000	131 000	63,98,000
1890-91 ...	251,000	556,000	73,000	52.10,000
1891-92 ...	259,000	506,000	65,000	51,86,000
1892-93 ...	327,000	543,000	38,000	61,75,000

Since the exportation of waste silk commenced, inferior cocoons, such as Tusser, Muga and Endi cocoons, have also been exported. The exportation of cocoons alluded to in the table just given includes chiefly Endi, Muga and pierced Tusser cocoons. Pierced mulberry cocoons are mostly utilized in Bengal for making *matká* cloths. The exportation of the inferior cocoons and the raw silk obtained from them is in fact again going down. It is a matter of great regret that, while the use of these cocoons and of the raw silk obtained from them is steadily increasing in European manufacture, the export of these articles from India is actually diminishing. The export of tusser into European markets first took place from

India. But it is the China tusser that is now recognized as the staple of European manufacture. This fact alone shows that the commercial enterprise of China stands at a higher level than that of India. The export from India of raw silk from the inferior cocoons since 1886 can be judged from the following table:—

Year.	Seers.
1886-87	221,000
1887-88	239,000
1888-89	309,000
1889-90	328,000
1890-91	187,000
1891-92	119,000
1892-93	120,000

283. *Consumption and Export of Silk Piece-goods.*—The superior silk fabrics made in India are nearly entirely used in the country. The quantity of silk piece-goods thus consumed in the country is very large,—very much larger than that exported to foreign countries. But there is at present no exact means of judging the outturn of native silk looms, nor of the consumption of indigenous silks in the country. The export of *coráhs* and other inferior silks has been diminishing for the last few years, as will appear from the following figures:—

			Rs.
In 1881-82	the export of silk cloths	was valued at	22,00 000
,, 1888-89	ditto	ditto	28,84,000
,, 1890-91	ditto	ditto	20 00,000
,, 1891-92	ditto	ditto	18,00,000
,, 1892-93	ditto	ditto	19,71,000
,, 1893-94	ditto	ditto	16,64,514

On the whole, however, the export of Indian silks into European countries has gone on increasing for the last 20 years, while it has been diminishing in other parts of the world. The subjoined table will show how the export of silk piece-goods into the different countries has been increasing or diminishing:—

COUNTRY.	IN 1876. Yards.	IN 1890. Yards.
England	1,328,229	1,430,850
France	470,902	723,776
Persia	20,709	23,427
Arabia	267,389	64,964
Egypt	18,907	8,163
Turkey	61,365	29,117
Indo-China	119,607	17,342
Ceylon	61,721	10,968
Mauritius	53,108	12,971

Of the Rs. 16,64,514 worth of silk pieces exported in 1893-94, England took Rs. 10,10,902 worth, and France Rs. 2,87,814 worth. From what has been said it can be easily inferred that the future advance of the Indian silk trade rests chiefly in the hands of England and India. The fortunes of the export trade, again, are very unstable, and its basis is only the poor classes of *coráhs*. The foregoing tables, though referring to the whole of India, practically have reference only to Bengal. Nearly the whole of the export of silk takes place from Bengal and Assam; and as the Assam silk finds its outlet through Calcutta, the whole of the silk trade may be regarded as the Bengal silk trade. The relative importance of the export of silk into the United Kingdom, France, and Italy of late years can be judged from the following table:—

YEAR.	TO UNITED KINGDOM.					TO FRANCE.					TO ITALY.
	Raw (Bales).	Chasams (Bales).	Cocoons (Bales).	Coráh (Pieces).	Tusser (Pieces).	Raw (Bales).	Chasams (Bales).	Cocoons (Bales).	Coráh (Pieces).	Tusser (Pieces).	Raw (Bales).
1	2	3	4	5	6	7	8	9	10	11	12
1891 ...	1,362	163	714	141,992	7,876	1,242	3,188	61	59.123	6,548	194
1892 ...	1,125	177	463	147,511	5,563	1,256	2,561	13	26,848	5,572	723
1893 ...	1,927	14	167	205,292	7,226	1.663	3,037	108	37,873	3,793	686
1894 ...	1,186	24	186	106,196	4,294	952	2.243	12	29,201	4,535	334
1895 ...	1,380	3	86	103,745	6,084	2,052	2,762	16	30,290	10,937	475

The principal shippers of raw silk, chasam, cocoons, *coráhs* and tusser from the Port of Calcutta are Messrs. Lyall, Marshall & Co., Messrs. Anderson, Wright & Co., Messrs. Walker, Goward & Co., Messrs. George Henderson & Co., Messrs. Graham & Co., Messrs. Irenee Brun & Co., Messrs. Balmer, Lawrie & Co., Messrs. Blackwood, Blackwood & Co., Messrs. Buskin & Co., Messrs. A. Ashmann & Co., Messrs. B. L. Sen & Co., Messrs. D. C. Roquitte & Co., Messrs. Shaw, Wallace & Co., and Messrs. Kettlewell, Bullen & Co.

284. *Import of Silk into India.*—The import of foreign silk thread into India has declined considerably of recent years, while the transhipment of Bengal silk thread into other parts of India has developed with rapid bounds during the same period. This is one of the most hopeful features of the Indian silk trade. The figures given below will show to what insignificant proportions the import trade in foreign silk thread has been reduced within recent years:—

YEAR.	QUANTITY. Seers.	VALUE. Rs.
1885-86	53,000	1,97,000
1886-87	18,000	81,000
1887-88	17,000	89,000
1888-89	6,500	30,000
1889-90	6,300	28,000

285. The import of silk into India consists chiefly in piece-goods. The total import of silk thread and silk pieces for four years since 1889 has been--

	Rs.
In 1889-90	2,84,51,590
„ 1890-91	2,50,14,300
„ 1891-92	3,01,46,980
„ 1892-93	2,81,76,510

From what has been said, it can be clearly inferred that India buys 2 to 3 crores of rupees worth of foreign silks. This is the least hopeful feature of the Indian silk trade. If India bought 2 or 3 crores of rupees worth of English silks, she could have consoled herself with the thought that it was a price paid for loyalty to England. But nearly the whole of this import is from Continental countries and not from England. England on her part has been showing anxiety of late for utilizing more of the Indian raw material. The condition of the English silk trade, again, has become most deplorable. England now imports annually about 24 crores of rupees worth of silk from other countries, while she exports only 3 crores of rupees worth. For England to buy 17 to 18 crores of rupees worth of silk pieces manufactured in France, Germany, Switzerland and Italy is not to her advantage. England has not always used foreign silks in such large quantities. For the last 30 years the import of foreign silks into England has steadily increased, while the export of English silks into other countries has steadily declined. The more silk thread she imports and the less of piece-goods, and the more piece-goods she exports, the better it is for her. But the course of the English silk trade has gone on exactly in the reverse order for the last 30 years. It is pretty nearly certain that England will be unable to compete successfully with other European countries in the silk trade. English labourers are not satisfied with the wages of even Rs. 60 per month. Italian and French labourers are quite as skilful as English labourers in weaving silk, but they receive about Rs. 30 to Rs. 40 per month. The labour strikes we constantly hear of from England are most intense in the case of silk factories. The foremost silk-weaving establishments in England (*viz.* those of Messrs. Lister and Company) sometimes find it difficult to work more than four days in the week. A few years ago Messrs. Lister and Company used to export about 50 lakhs of rupees worth (£30,000) of velvet per annum to America alone. The American export of velvet of this Company has gone down to about 6 lakhs of rupees (£3,600) worth per annum. There seems to be only one means now by which England can combat successfully with the Continental silk trade, *viz.* by transferring the centres of competition from Manchester, Manningham, and Leek to Baluchar, Mirzapur, Benares, Amritsar and Srinagar. Such a policy alone can restore the commercial supremacy which England enjoyed in the days of the East India Company. The interests of England and India are identical in regard to the silk trade. Indian silk-weavers are artisans of no mean order. Skilled Indian labour guided by English enterprise can produce silks of European excellence and finish. Indian weavers work on the monthly wages of Rs. 5 or Rs. 6 only. The interests of India and England in this matter are so closely blended together that it is desirable to give here two tables detailing the present position of the import and export trades of England.

286. *Import of Silk into England.—*

Description of Article.	1890.	1891.	1892.
	£	£	£
(1) Raw silk from China	986,000	1,069,000	544,000
Ditto do. Japan	9,000	120,000	36,000
Ditto do. Bengal	94,000	131,000	110,000
Ditto do. other countries	301,000	321,000	292,000
(2) "Waste" silk	792,000	823,000	528,000
(3) Thrown do.	529,000	501,000	441,000
(4) Silk pieces	5,314,000	5,451,000	5,891,000
(5) Do. ribbon	2,476,000	2,514,000	2,626,000
(6) Mixed silk pieces	3,347,000	3,051,000	2,771,000
Total import	13,848,000	13,981,000	13,239.000

287. *Export of Silk from England.—*

Description of Article.	1890.	1891.	1892.
	£	£	£
(1) Thrown silk	477,000	516,000	322,000
(2) Silk pieces	211,000	269,000	263,000
(3) Do. handkerchiefs, scarfs and shawls	511,000	525,000	446,000
(4) Silk ribbons	16,000	8,000	8,000
(5) Do. lace	211,000	238,000	337,000
(6) Other silk goods	164,000	167,000	159,000
(7) Mixed silk pieces	1,114,000	534.000	439,000
Total export	2,704,000	2,257,000	1,937,000

288. *Import of Silk Thread into England.*—It has been said already that the import of silk thread into England is steadily declining. The decline in the export of raw silk from India taking place correspondingly with the decline in the import of raw silk into England, the mutual relations of the two countries in this trade will be easily understood to be very close. The table given below will show how the silk-manufacturing industry of England is steadily going down for 30 years owing to the decline in the import of raw silk:—

YEAR.	Number of bales (of about 2 maunds) imported.
1854	75,700
1857	11,300
1870	60,820
1880	33,772
1885	16,692
1886	23,062
1890	15,277
1891	18,718
1892	10,831

289. *Competition with France.*—Of all countries in the world, France exports the largest quantity of silk goods to other countries, and England buys the largest quantity of silks exported from France. In 1890, 1891 and 1892 France exported 273,928,000 francs, 245,711,000 francs and 254,058,000 francs worth of silk goods, nearly half the quantity being bought by England. In 1891 France exported 102,843,000 francs worth of silk goods to England, and 116,872,000 francs worth in 1892. Whenever there is any large increase in the import of foreign silk goods into France, French statesmen protect the interest of their favourite industry by the adoption of adequate fiscal manœuvres. The import of foreign silk goods into France in 1890, 1891 and 1892 was respectively represented by 639,200,000 francs, 682,060,000 francs and 60,538 francs. The sudden falling off of imports in 1892 was due to the fact of an import duty of 4 francs per kilogramme of European-manufactured silk imported into France

from the 1st February 1892. Indian *coráhs* and other silks are still received in France free of duty. France, indeed, no longer looks upon England as her rival in the silk trade: she occupies the same unrivalled position which England did at one time. In fact, for the last few years France has been looking upon Italy as a possible rival. Italian labourers can work cheaper than French labourers, and labour strikes also have become quite common in France. The progress Italy is making in the silk trade would lead one to expect her occupying the first place at no distant future.

290. *Nature of the Decline of the Indian Silk Trade.*—(1) In the days of the East India Company nearly the whole of the eastern trade of Europe in silk was with India. In course of time the doors of the Chinese and Japanese trade were thrown open to Europeans. The excavation of the Suez Canal gave an impetus to this trade with the Far East, and to France and Italy launching out in the competition. With the help o these two European countries China and Japan have outstripped India in the export trade in silk.

(2) The policy of interference with trade or *protection* is not in favour with the British Government. France and Italy do not believe in the principle of free trade. Whenever the Governments of France and Italy deem it expedient to encourage trade by public subsidy with the expenditure of public revenue, they do so; and whenever they find it expedient to discourage foreign traders they do so by the imposition of prohibitive duties. The duty imposed in France against foreign piece-goods since the 1st of February 1892 has been already mentioned. Another Act was passed in France on the 13th January 1892, by which every cocoon-rearer receives out of the public treasury a subsidy of half a franc (nearly 6 annas) for every kilogramme (about 1 seer) of cocoons he produces. In 1892 the French Government spent 3,827,682 francs (*i.e.*, about 20 lakhs of rupees) in paying this subsidy or reward to cocoon-rearers. As a direct effect of this encouragement on the part of the French Government, 615,000 seers of raw silk were produced in France in

1892, that is 49,000 seers more than in the previous year. Under the same Act of the 13th January 1892 silk-reelers also received a bonus of 3,700,000 francs (*i.e.*, about 19 lakhs of rupees) from the public treasury in 1892. To encourage the silk-throwsting industry of France the French Government has imposed since 1892 a duty of 3 francs per kilo on imported thrown silk. Steamer companies engaged in commerce also receive subsidies from the French Government. This also has an indirect effect in encouraging the silk industry of France. The enhanced rate of import duty on thrown silk and piece-goods imposed in 1892 has not only given an impetus to the native throwsting and weaving industries of France, but it has also brought about an increase of revenue to the State. From the import duty on silk the French Government derived a revenue of 885,000 francs, 810,000 francs and 1,719,000 francs, respectively, in 1890, 1891 and 1892. The various methods by which the silk industry of France has been revived are being closely imitated by Italy, China, Japan and other countries. That Indian silk will be able to compete successfully with silks from other countries in the European market without Government protection is not very likely. We should, therefore, depend mainly on the development of the internal trade in silk. This development can go on, irrespective of the fiscal policy that may be adopted by foreign Governments, if the native spirit of enterprise can be fostered and kept alive. For the last eight or nine years the use of native silks has been increasing all over India. This increased demand has been specially perceived in the Jangipur centre of Murshidabad, where the silk-weaving industry is undergoing quite a revival.

(3) It is unfortunate for India that London is no longer the central mart for the silk trade, Lyons and Milan being now considered the two centres for the European silk market. Even English merchants buy most of their silk now in these two places. It is unfortunate both for England and India. It is not altogether impossible for India to supply all the raw material for the English silk-manufacturing industry as she did in the days of the East India Company. In those days,

however, organized action was possible, the Government being directly interested in all departments of sericulture, including the propagation of mulberry plants. Since the British Government in India withdrew from trade, organized action in this matter has become difficult. One source of common effort, however, is still open, *viz.*, for Natives and Europeans to keep themselves acquainted with facts, and to pursue their respective callings with knowledge and intelligence, in the same way as sericulture is being pursued in more civilized countries.

(4) Instruction in sericulture is imparted in schools in France and in Italy. Such systematic instruction is the basis of all real improvement. It is by education and combined action that sericultural improvement has taken place in other countries, and it is the want of these that accounts for India being behind other sericultural countries. The recent foundation of a sericultural school at Rampur Boalia may lead to important consequences, if interest in this establishment can be kept up.

(5) European raw silk and Chinese and Japanese filature-reeled silk are worth 6 to 7 rupees more per seer than the Bengal filature-reeled silk. The price of cocoons and the cost of labour being less in Bengal than in any other country with the exception of China, Bengal has, no doubt, some advantages over most sericultural countries; but these advantages are more than made up for by the inferiority in the quality of the Bengal silk. The three methods by which improvement can be effected in the quality of the Bengal silk thread have been already described. These are (*a*) introduction of European cocoons, (*b*) export of rewound and thrown silk, and (*c*) use of *jette-bous* for reeling. Notwithstanding all disadvantages, Indian silk can have a very good field in the European market if the quality of this silk can be improved to the European standard by the adoption of the methods indicated.

(6) Bengal mulberry costs Rs. 20 to Rs. 25 per bigha per annum to keep it in cultivation. If large mulberry trees can

be propagated, this annual outlay will be found unnecessary. Silkworms in other countries are reared with leaf gathered from trees, and not from little shrubs. An organized attempt to propagate mulberry *trees* should be looked upon as a very important scheme for ameliorating the silk industry of Bengal.

(7) The diseases of silkworms is another obstacle to sericulture. The various methods that can be adopted to combat this obstacle successfully have been fully described in Part II of this book. If cocoon-rearers are convinced of the fact that it is possible for them to obtain certain crops of cocoons by adopting a definite plan of work, which it is easy for them to learn, the silk trade of Bengal can prosper irrespective of all other considerations. By following Pasteur's system of seed selection and other methods of avoiding or combating silkworm epidemics described in this book, a number of cocoon-rearers of Malda, Birbhum, Murshidabad, Rajshahi and Midnapore are getting 16-anna crops every time and becoming rich. This movement once begun can now be easily carried on, and model nurseries established in every silk-rearing *joar* in Bengal, which will not only throw into circulation a large quantity of healthy seed, but also popularize rational and scientific methods of sericulture. If these methods can be taught in schools within easy reach of the model nurseries, the knowledge can spread still faster, and attempts on the part of the cocoon-rearers who have learnt the new methods to keep the knowledge as a secret to themselves can be frustrated.

(8) The poverty of native silk-weavers is another obstacle to the progress of the industry. Mirzapur (Jangipur) silk *saris* and dress-pieces, though almost equal to European silk in appearance, are not so largely used in the country as they deserve to be. The reason for this is twofold:—

(*a*) It is extremely difficult to make any organized effort for the sale of these silks in the same way, for instance, as organized efforts are made for the sale of foreign silks in this country, as our weavers are illiterate and poor. When any attempt is made to advertise their goods on their behalf, such advertisement meets with unusual success; but they cannot expect other people to advertise their wares for them always. They should take their best products to exhibitions held in large towns, and also hawk about their goods from house to house, bringing them to the notice of rich people. If a few middle-class Bengalis with a capital of one or two thousand rupees only were to set about selling Mirzapur silks in large towns, carrying them about from house to house in boxes, like Parsis or Jews, they could soon pull up the industry while carrying on a lucrative trade for themselves.

(*b*) Weavers are just as much in the hands of money-lenders as cultivators. They cannot sell the products of their loom at a more reasonable price than they do, as they have to pay interest for their loans at the rate of 20 to 25 per cent. per annum. If they had not been so hopelessly involved in debt, they could have raised their status and sold their goods cheaper at the same time. The money-lenders take no interest in the actual manufacture or sale of the cloth, but it is they who suck the vitality out of the industry, and prosper. If some scheme can be devised for saving the weavers from the hands of the money-lenders, of buying up their goods cheaper, and of selling them to the public also cheaper than they are at present sold, the industry can be benefited most materially.

291. *Organized Action.*—The various methods that have been suggested for ameliorating the condition of sericulture should be given fair trial by an association composed of persons representing the different branches of sericulture. Such an organization would be fruitless unless Natives and Europeans combine to make it a success. An association formed in the interest of the export trade in raw silk alone can effect little in ameliorating the condition of the trade. An association in which weavers, silk-reelers and cocoon-rearers can be made to join with equal enthusiasm may be the means of pioneering immense improvements. The working of such an association would be considerably facilitated by a journal, conducted in the vernacular language, by which the members representing the different branches of sericulture could get

information on their own respective subjects, and introduce improvements in their methods of work. It is by dissemination of knowledge that improvements can be chiefly effected, and it is the want of knowledge that has been the chief hindrance hitherto. The interests of England and India are so closely related in sericulture that England is likely to take up this question of improvement of Indian sericulture at no distant future, and bring the various efforts for the improvement of trade and manufacture to a successful issue. Indians, on the other hand, will learn to recognize themselves, as time goes on, that they are only different sects for the mighty British nation. In course of time this fact will be recognized by Indians with a feeling of pride. In course of time, also, Indians will be owned and respected by England and by the rest of the world as part and parcel of the British nation. It is this national feeling that is desirable for India, and it is this which lies at the foundation of the question of the revival of the British silk industry. In no other trade does sentiment come into play so largely as in silk trade, and a healthy national, or rather Imperial, sentiment actually lies at the bottom of the question of the revival of the British-Indian silk trade. The sentiment of nationality which Indians are at present taking pains to establish is only an obstacle to commercial enterprise. It should give place to a broader sentiment which is helpful to British-Indian art and commerce.

APPENDIX.

Questions, with appropriate answers, for the use of Officers inspecting Sericultural Nurseries.

Situation of Nursery.

1. Is the nursery situated close to trees? [Yes.]

2. Is it situated close to a river, *bil*, or a large tank? [Yes.]

3. Is the entrance to the rearing-room directed away from the prevailing wind at the time? [Yes.]

4. Do any of the open windows give direct access to wind? [No.]

5. Is the nursery situated close to any dusty road? [No.]

General Sanitation.

6. Are the surroundings of the nursery clean and dry? [Yes.]

7. Are the inside and outside of the rearing-room and the courtyard properly *leped*? [Yes.]

8. Do the rearing-rooms feel well ventilated? [Yes.]

How many ventilators are there? [Six.]

How many of them are open? [All—directed away from the prevailing wind.]

9. Is there any bad smell inside or outside the rearing-rooms? [No.]

Does any smell proceed from any article connected with silkworms or the mulberry plant? [No.]

10. Do the rearing-rooms appear clean enough for comfortable human habitation? [Yes.]

Are they so inhabited? [Yes.]

11. Is litter hoarded in corners to keep the rooms warm to hasten maturity? [No.]

12. Is delitage done daily with thread nets? [Yes.]

13. Is *leping* done daily? [Yes.]

Disinfection.

14. What quantity of sulphur is in stock? [About half a maund.]

What quantity of sulphate of copper is in stock? What quantity of quicklime? [About 10 seers; about 2 maunds.]

15. What quantity of sulphate of copper was used on the last occasion? [Half a seer.]

16. Within how many hours after the preparation of the solution was it used up? [5 hours.]

17. How is the proportion between sulphate of copper and water regulated? [1 chitak of sulphate of copper is used for every *kulsi* of water (about 6 seers).]

18. Is washing of nets done with plain water after the sulphate of copper wash? [Yes, within a quarter of an hour.]

19. Are the bamboo stands washed with sulphate of copper? [Yes.]

20. Is sulphur fumigation done soon after the preliminary washing and *leping* while the room is still wet? [Yes.]

21. Are thread nets and sheets of eggs kept out after sulphate of copper wash when sulphur fumigation of rearing-room is done? [Yes.]

22. Are spinning screens cleaned, passed through fire, sprayed with sulphate of copper and then subjected to fumigation? [Yes.]

23. When was muscardine last noticed in this nursery or in the neighbourhood?

24. About how many worms died of muscardine in the nursery?

25. What steps were taken to arrest the disease in the nursery or in the neigbourhood? [Sulphur fumigation after thorough delitage was done, and repeated until the outbreak ceased.]

26. How many days' fumigation did it take to eradicate the outbreak? [About 6 days' fumigation.]

27. What was the quantity burnt on the first day? What on subsequent days? [1 seer on the first day; 1 chitak per day afterwards.]

28. Is there a pan kept for sulphur fumigation? [Yes.]

29. Is the sulphur powdered and then allowed to melt in a pan on slow fire? Or is it scattered on burning fuel? [It is powdered and melted in a pan.]

30. Are lime-bags daily used at the time of delitage? [Yes.]

DISPOSAL OF LITTER.

31. Is the delitage done in rearing-rooms, or in the ante-room, or in the verandah of the rearing house? [In the ante-room.]

32. Is a vessel containing powdered lime or sulphate of copper kept in the place where delitage is done? [Yes.]

33. Where is the litter removed to afterwards? After how long? [To a pit in the direction opposite to the direction of the wind. Soon after delitage is over.]

34. How far away from the rearing-house is the pit where litter is kept? [100 yards.]

35. Is the pit at present in use towards the direction of the wind? [No.]

36. Is the litter given to cattle to eat? Where is the dung of cattle fed with litter conserved? [Yes. The dung is conserved in a pit situated as above.]

37. For how long is the litter or the dung allowed to remain in pit before it is used as manure? [Over 8 months.]

38. Is silkworm litter used as manure for mulberry in the nursery or in the locality? [No.]

SPACING.

39. What is the length and width of each rearing-room? [21 cubits × 13 cubits (or 13 cubits × 9 cubits.]

40. How many doors, windows, and fly-traps has each? [1 door, 3 windows, 6 fly-traps.]

41. How many trays are kept in the room? [70 (or 30).]

42. Are young worms kept particularly thin on trays? [Yes.]

43. What is the size of each *dálá?* [Of 3½ cubit diameter.]

44. What is the approximate quantity of full-size worms (in *káhans*) on each? [1½ *káhans* (2½ in very cold weather).]

45. How often at each age is thinning done? [Twice.]

46. Is thinning done with hand or with nets? [With nets.]

47. Do worms look even? [Yes.]

48. What are the means employed for securing evenness of the worms? [(1) Placing late worms high up on stand, (2) giving these an extra feed, (3) separating worms, late in moulting, with nets.]

49. Are worms of the same age only kept in the same room? [Yes, of about the same age.]

PEBRINE (*Katá*).

50. Is the proprietor of the nursery able to use the microscope, in the selection of seed free from pebrine? [Yes.]

51. How many of his relations have been taught this?

How many others?

Their names.

52. How many days after the laying of eggs does seed selection commence? [5 days.]

53. Can the proprietor and the apprentices explain the difference between full-formed pebrine corpuscles and grasserie crystals, and between these and air bubbles? [Yes.]

54. Do they know the difference between pebrine corpuscles and spores of flacherie? [Yes, the latter being five times smaller.]

55. Can they distinguish between the conidia of muscardine and pebrine corpuscles? [Yes, the former being comparatively flatter, larger and more circular.]

56. Do they look for any other disease save pebrine while selecting the seed with the microscope? [No.]

57. Where are the spinning screens kept? Is the direction of the wind towards the place where spinning screens are kept? [In a separate shed situated at some distance, and away from the prevailing wind.]

58. Are spinning screens, with ripe worms or cocoons on them, kept inside rearing-rooms where there are silkworms? [No.]

59. Are pierced cocoons or other cocoons kept in the rearing-room when there are worms in them? [No.]

60. Has exchange of seed been resorted to? [Yes.]

Whence was the seed last brought? Was it from a demonstration nursery or an ordinary village rearing house? [From a demonstration nursery situated in soil of a different character.]

61. How many moths can the proprietor and each apprentice examine daily with the microscope? [Over 200.]

62. Has carbon bisulphide been used since the last inspection with the object of giving the crop the best chance to be sold for seed before any portion of it is killed? [Yes.]

MUSCARDINE (*Chuná*).

63. Does the litter show any worms dead of muscardine? [No.]

64. Can the proprietor and each apprentice describe the method of dealing with this epidemic when it does break out? [Yes, (1) delitage, (2) *leping*, (3) fasting the worms, (4) fumigating in proper manner, (5) repeating delitage and fumigation.]

65. Is the litter thick on any tray? [No.]

66. Are moultng worms seen buried in litter? [No.]

67. How far removed is the nursery from the nearest filature and the nearest silk-rearing village? [Over half a mile.]

GRASSERIE (*Rasá.*)

68. What is the character of the leaf with which young worms are fed and with which full-sized worms are fed? [(1) Tender, (2) mature and full-grown.]

69 Has any provision been made for propagating large mulberry trees in connection with the nursery? [Yes.]

70. Is feeding discontinued too soon at moulting periods? [No.]

Is feeding done too soon after the moulting period, or are the worms allowed to get keenly hungry before feeding is resumed? [Feedings not resumed too soon after the moulting, but the worms are allowed to get impatient with hunger.]

Flacherie (*Kálshirá*).

71. Is seeding done on paper? [Yes.]

72. Are sheets of eggs dipped in sulphate of copper solution (1 : 100 or 200) at least twenty-four hours before hatching? [Yes.]

73. Are pierced cocoons and refuse of all kinds removed from the nursery, and all appliances disinfected, before hatching takes place? [Yes.]

74. Is the leaf used suitable for the particular class of worms reared? [Yes, tender leaf is used for *Chhotapalus* and stronger leaf for *Nistáris* and *Barapalus*.]

75. Is the leaf on the trays dusty, harsh, muddy, stained, heated or wet? [No.]

76. Is the leaf in stock properly conserved? [Yes.] Is there a thin sheet wrapped round it? [Yes.] Are the stalks kept standing? [Yes.] Does the heap feel hot or sweating? [No.]

77. How often is feeding done at the 1st, how often at the 2nd, how often at the 3rd, how often at the 4th, and how often at the 5th age? [5, 5, 4, 4 and 3 times, respectively.]

78. Is sweeping or *leping* practised inside the rearing-room? [*Leping*.]

79. Are the surroundings of the nursery dusty? [No.]

80. Is there any smell of rotten mulberry or silkworm litter inside or outside the nursery? [No.]

81. How far is the nearest silk-rearing house from the nursery? [Over 200 or 300 yards away.]

82. Is cleaning of *dálás* done inside or outside the rearing-room? [Outside.]

83. Is there any provision for ventilation? [Yes.]

84. Does the proprietor understand the method of using quicklime against flacherie? [Yes, he opens out the closed vessel of quicklime when the rearing-room feels damp.]

85. Is rearing done when it is too hot or cold? [No.]

If it is, what precautions are taken to avoid gatine and flacherie? [Against gatine, rearing is done in a room facing north and daily *leping* of floor and walls practised. Against flacherie, quicklime is used.]

86. What precaution is adopted if a dead worm is noticed on a *dálá*? [The worm is removed, and the spot dusted with lime or sulphate of copper dust.]

87. What is the temperature inside the rearing-house early in the morning? [70° to 80° F. These are the extreme limits in the cold and hot weathers.]

What at 4 P.M.? [75° to 85° F.]

What plan is adopted for securing uniformity of temperature—

(*a*) In the hot weather? [(*a*) Keeping windows and ventilators in the north open and sprinkling water outside.]

(*b*) In the cold weather? [(*b*) Keeping fire in, leaving a ventilator in the south open.]

Court (*Rángi*).

88. Is the mulberry plantation in an open place, or is it too much shaded with trees? [In an open place.]

89. Are big worms ever fed with leaf from a new plantation? [No.]

90. Are the worms given sufficient quantity of leaf, or do they look starved and hungry? [They are fed 4 to 5 times a day at the early stages, and 3 times a day at the last stage.]

Gájlá-Cocoons.

91. Is there a room besides the rearing-room which can be kept shut up and air-tight? [Yes, the ante-room can be kept so shut up.]

92. Is a supply of quicklime kept in properly covered tin boxes? [Yes.]

93. When was the precaution last adopted for avoiding *gájlá*-cocoons?

Fly-parasite and Dermestes.

94. Is seeding done in a room separate from the rearing-room? [Yes.]

95. Are cocoons threaded and hung up for seeding, and is a hollow vessel kept underneath where the grubs of the parasite can drop down? [Yes.]

96. Is rearing done at regular intervals of two or three months by every rearer in the *joár*? Or are irregular rearings quite common? [Regularity of *bunds* is observed by all the rearers in the *joár*.]

97. How many fly-traps are in use in the nursery? [Six.]

Are they properly placed? Is there clean water in them? How often is the water changed? Are there any flies dead in the trays? Do the traps smell? Is any kerosine oil used? [Yes, immediately above the windows. Yes. About once every day. Yes. No. Yes.]

98. Are the windows and the ventilators fitted with fine *chiks* or wire-gauze? [Yes.]

99. Is there an ante-room to the rearing-room? [Yes.]

100. Are young worms kept in wire boxes? Are the wire boxes in proper order? [Yes. Yes.]

101. Are dermestes killed whenever they are seen? [Yes.]

MULBERRY CURL.

102. Is the mulberry curled? [No.]

103. Are weeding and manuring properly done? [Yes.]

104. Does the plantation look vigorous? [Yes.]

105. Is the plantation segregated from other neighbouring plantations? [Yes.]

106. Has the kerosine emulsion treatment been ever practised after the autumn-cleaning (*murá-kátá*)? [Yes.]

THE *Barapalu* OR EUROPEAN SILKWORMS.

107. Has the *barapalu* or the European silkworm ever been reared in the nursery?

108. What steps have been taken to popularise the rearing of these high-class cocoons? [Hatched worms are distributed.]

109. Was hatching regular, if these worms have been reared? [Yes, the hatching was complete in less than a week.]

110. What was the hibernating temperature allowed? [50° to 60°F. in the case of *barapalu*, 32°F. in the case of European silkworm eggs.]

What was the incubating temperature? How was uniformity of temperature secured? [74°F. By keeping eggs inside spacious, sealed, but porous *handies*, in proper hibernating temperature, and with lamps and shutting and closing of windows at the incubating period.]

Endi SILKWORMS.

111. Has anything been done to introduce the rearing of *endi* silkworms? [Yes, rearing of this worm is occasionally done here in the rainy season.]

112. What special precaution has been taken to keep the eggs and worms alive from March to June? [Small quantities have been reared in a very damp room to keep the seed alive.]

113. What is the method of spinning adopted? [The pierced cocoons are boiled with ashes obtained by burning tender plants, well washed afterwards, and then spun as pierced mulberry cocoons are spun.]

DISTRIBUTION OF SEED, &C.

114. Does the proprietor of the nursery announce the date of ripening of worms each time, by beat of drum or otherwise, in the local *háts* and villages? [Yes.]

115. Does he send a notice in proper form each time he has a crop to the Agricultural Department at least 20 days before the ripening of worms? [Yes.]

116. How many post-cards containing the blank form of notice has he in stock? [Six.]

117. Does he distribute printed notices of sale of seed sent to him for the purpose from the Agricultural Department? [Yes.]

118. Which villages have been supplied with seed from this nursery more than once during the preceding year?

119. What report did the villagers give as to result obtained by them the first time when they came for seed the second time?

120. Has the proprietor been sending samples of seed-cocoons to the Agricultural Department each time? [Yes.]

121. What was the proportion of pebrine found by examination of samples during the last three *bunds*? [Less than 10 per cent. each time.]

122. How many pierced cocoons went to a *tolá* during the last three *bunds*? [Less than 100.]

123. Has the proprietor ever sent seed cocoons or eggs by post?

124. On what day are seed-cocoons despatched? [4th day.] On what day eggs? [3rd day.]

125. Have any complaints been received about this nursery regarding faulty or late despatched or insufficiency of quantity?

126. Has seed been received too late in this nursery from any other nursery? Did the fault lie with the post office or with the proprietor of either nursery?

127. Do the fellow villagers of the proprietor think his (1) seed-rearing and (2) cocoon-rearing business to be prospering? What does he think himself?

128. What are the wants of this nursery at the present stage of its growth?

129. What wants must be supplied by the proprietor (1) within the next three months, and (2) within the next year on pain of forfeiture of the appliances lent to him by the Agricultural Department?

130. Does the proprietor require the help of the Department in any matter? [Yes; in renewing the mirror of his microscope and in arranging for postal delivery and despatch at least twice a week.]

131. Is any substantial cocoon rearer accustomed to buying seed from this nursery anxious to buy a microscope and other special appliances?

132. Is the house of such a rearer situated in a locality suitable for the establishment of demonstration nursery?

IGNCA LIB
86-3188
Deptt of Arts
12-12-86
GOVT. OF INDIA

THE END.

B. S. Press—19-2-1919—2930J—200—C. W.

7/86
£ (B·HI) + (R·HI).

₨ 600

F-31/86
2166

Eco cs & Handicrafts

R/86/Sci/202/4

4. Mukerji N.G : Handbook of Sericulture : Pp. ii, 298 ; with 34 fig ;
9½" x 6¼" : Calcutta : 1919. 600.00

CALCUTTA :
BENGAL SECRETARIAT BOOK DEPÔT.
1919.